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Ascochyta Blight and Winter Sowing of Chickpeas

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Ascochyta Blight and Winter Sowing of Chickpeas

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas

edited by

M.C. SAXENA and K.B. SINGH
The International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

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Foreword

The advancing of sowing date of chickpeas from spring to winter is undoubtedly a major breakthrough in the research on food legumes in the lowland Mediterranean region of West Asia and North Africa. This has been achieved thanks to the research efforts that led to the development of the ascochyta blight resistant cultivars with high yield potential.

The research on winter sowing of chickpeas was initiated well before the establishment of the International Center for Agricultural Research in the Dry Areas (ICARDA) by its forerunner, the Arid Lands Agricultural Development Program (ALAD). With the establishment of ICARDA, it became the major crop improvement objective of its food legume program. The greatest boost to the research efforts in this direction, however, occurred when in 1978 ICARDA and the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) decided to pool their resources to carry out research on kabuli chickpeas. ICARDA became the principal base for this program.

After 4 years of intensive research at ICARDA, the hypothesis that winter-sown chickpeas produce substantially higher yield than spring crop was put to wider test during the 1979–80 season through the Chickpea International Yield Trial-Winter (CIYT-W) in nine countries of the region. On-farm trials were carried out in different chickpea-growing areas of Syria. The hypothesis stood the test, and the stage is now set for the next two steps: evaluation of the practice on larger scale and in wider areas, and identification of possible contraints to the adoption of the practice.

A workshop was, therefore, organized at the Aleppo Center of ICARDA in Syria, from 4 to 7 May 1981, to focus attention on ascochyta blight and winter sowing of chickpeas in the West Asia and North Africa regions. The workshop, which was the first of its kind, was attended by 39 participants from nine different countries of the region. All aspects of the ascochyta blight and agrotechnology and socioeconomic considerations in the winter planting of chickpeas were thoroughly deliberated through the presentation of papers and in-depth discussions following the presentations. Group recommendations were formulated to provide guidelines for, and to motivate, the future work. All these are contained in the present proceedings of the workshop.

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It is my hope that the publication of the proceedings will help disseminate information on the present status of research on ascochyta blight and winter sowing of chickpeas, and will stimulate the scientists to carry this research to farmers' fields. This will encourage intensification of scientific research to solve new production problems which may arise restraining the increased chickpea production.

Mohamed A. Noui
Director General
ICARDA

Editors' Note

The idea to hold this workshop on Ascochyta Blight and Winter Sowing of Chickpeas originated from Dr. G.C. Hawtin, then Leader, Food Legume Improvement Program and now Deputy Director General (International Cooperation) of ICARDA. We express our deep sense of gratitude to him. Dr. M.E. Ibrahim, then Acting Head of the Training and Communications, ICARDA, and his staff provided valuable assistance in organising this workshop for which we are thankful to them.

This publication contains the proceedings of the workshop. The editorial assistance of Dr. S. Varma, Science Writer/Editor, and the support of Mr. Larry Chambers, Head of Documentation and Communications, ICARDA, facilitated greatly the preparation of the manuscript of this publication. We are indebted to them. We also wish to acknowledge the help of the staff of Martinus Nijhoff for guiding the text through the final stages of composing and printing.

M.C. Saxena
K.B. Singh
Editors

Opening Session

Welcome Address

MOHAMED A. NOUR
Deputy Director General, ICARDA

I would like to open this meeting by introducing Dr. Harry Darling, the Director General of ICARDA, who will give his opening statement. But before giving the floor to Dr. Darling I would like also to take this opportunity to welcome our distinguished guests from the various parts of the world to ICARDA and say to them that they have brought rains with them which is a good sign. We say in Arabic "Your feet are green"; I do not know whether this expression is used in other places but certainly this rain will be adding a little bit of greenery to the already green scenery of this part of the world.

There are a few announcements that I would like to make, concerning your program which each one of you should have received by now. If you have a look at your program you will find that the first day will be devoted mainly to a visit to ICARDA's experimental farm at Tel Hadya, where you will see various experiments and discuss aspects of breeding, agronomy, weed control and other research areas concerning chickpeas. Your second day will be entirely here in the conference room and it will be devoted to the presentations on ascochyta blight. Your third day will again be a field day when you will visit our off-station sites and on-farm trials.

In the closing session we will have discussions and approval of recommendations on ascochyta blight and I would like to request you to address your recommendations/ comments on this subject to Dr. Nene or Dr. Singh. Also, after tea, there will be a discussion and approval of recommendations on the winter sowing; please address your recommendations/comments on this subject to Dr. Hawtin or Dr. Nygaard. I hope you will not miss to send or hand over your comments to them. Your comments and suggestions will make the proceedings meaningful.

It is my real pleasure now to ask Dr. Darling to take the floor and give his opening statement.

Opening Address

H.S. DARLING
Director General, ICARDA

Chairman, Ladies and Gentlemen,

My thanks for allowing me this opportunity to participate in this workshop on ascochyta blight and winter planting of chickpeas to which I look forward with enhanced pleasure because I am afraid, I can only give one day to it. I do begin by wishing all concerned a success which the subject fully deserves, and which I feel it will obtain. May I join Dr. Nour in extending a warm and wet welcome to you all here to Aleppo. The wetness I cannot honestly claim we arranged it, we welcome it but it is unexpected, unusual and a privilege for all of us. I only hope it will not mar in any way our visit today to Tel Hadya field site. I would like to welcome you here and say how glad I am that you made it in rather fragile times without difficulty. I am sure that you will find your stay here well worthwhile. All our services are available to make your time as enjoyable as we possibly can. May it prove to be so.

I think this subject of ascochyta blight and winter planting of chickpeas is a very important topic and I am glad that the privilege has been given to ICARDA to lead the way with the workshop on this subject which in its own way is a breakthrough of both scientific and practical importance. I am grateful for the privilege given to me to say a few words on the subject as we open our workshop.

ICARDA from the very beginning has had a deep interest in research on chickpeas in the West Asian and North African region. And this is not just a casual interest, it is built into our mandate. We are charged by mandate from the world authority that established us to carry out such research but in a regional context. In the ICARDA region which is large enough from Pakistan in the East to Morocco in the West, from Turkey in the North and the Mediterranean area down to Sudan in the South, we have some 22-24 countries. Chickpeas are an important crop to several millions of people in this region. The work on chickpeas is largely conducted in our Food Legume Improvement Program or FLIP, as we like to call it, which also has a mandate for lentils and faba beans and some interest in starting work on dry peas as well. But for the time being we are working only on chickpeas, lentils and faba beans.

As you all know, and may I say how pleased I am, that ICRISAT has fielded an adequately strong team for this occasion. ICRISAT has a world-wide mandate for chickpeas. There is no reason at all why these two spheres of interest should not compliment and support each other. In these days of shrinking values of money due to inflation, recession and falling budget, those who support stations like ICRISAT and ICARDA are becoming very conscious that no money be wasted through unnecessary duplication of work. It has been a very strong talking point for the donors that support us both in legume and cereal work that we should not duplicate work being done in other centres. For example, with respect to cereals we had a fair amount of insistence that we do not repeat what CIMMYT is doing almost at our own doorstep. And the same might well have been said about the work on chickpeas with ICRISAT having a world mandate and ICARDA a regional mandate. I think with wisdom ICARDA and ICRISAT saw this criticism coming and arranged to integrate the programs and run them as one program without any wasteful and unnecessary duplication of work with full cooperation and pooling and sharing of resources.

I am happy to say, and I hope Dr. Swindale of ICRISAT agrees, that the set up is working very well indeed. We at ICARDA are pleased with it and I take this opportunity to thank ICRISAT for the support, for its share in the leadership and for the way it pulls its weight fully in this double job. In support of this combined program a senior breeder from ICRISAT was posted by that centre to ICARDA in 1978 to work here on chickpea problems. Subsequently in 1980, a second breeder was asked to come here. I do not think there will be further increase in the number of positions but there is a move afoot that ICRISAT will post a pathologist here in place of the second breeder to help in this vitally important area of the work which of course relates to ascochyta, the theme of our workshop today. A further sharing of the work was the fact that, by the initial agreement, ICARDA accepted the responsibility for work on the kabuli type chickpeas which are prevalent in the ICARDA region and also are widely grown in parts of southern Europe and Latin America, while ICRISAT retained the responsibility for the desi types which are common in the Indian subcontinent and so very important there. And this sharing has again worked well. In fact I think this is to the credit of all concerned at the actual work level, far below the levels of directors, that everything is working out so well and I would like to thank the staff concerned.

As far as work is concerned, ICRISAT did some initial work on ascochyta blight but as this progressed it became obvious that this work could more suitably be carried out at ICARDA under the conditions we have here. The disease occurs naturally here, is a regular burden to us and was an obvious target for local work. Here again the partnership arrangement worked well and the two centres agreed that research at ICARDA would concentrate mostly on ascochyta blight, while the main initiative for research on other important chickpea diseases

including stunt virus (pea leaf roll virus), root-rots and wilts, should remain with ICRISAT. This sharing has again proved effective. To help us in our work here at ICARDA on ascochyta blight, ICRISAT had stationed a pathologist from their core program for 2 – 3 months a year both in 1980 and 1981.

Since the main theme of our workshop is winter planting in relation to ascochyta blight, may I take a few minutes, Mr. Chairman, just to review briefly the history of this. The first work on winter planting of chickpeas was conducted not by ICARDA but by its forerunner, the Arid Land Agricultural Development Program (ALAD) which worked very much in this area,with support from the Ford Foundation. This first work on winter sowing was done in 1974/75 in Lebanon at Kfardan and here the object was just to test out whether there was enough hardiness in chickpea to stand the winter and to find out if the lack of cold hardiness in chickpeas had been the reason for the local farmers to grow the chickpea as a spring-sown rather than as a winter-sown crop. Well, I was not here at that time but I gather, to the surprise of all concerned, that all the material survived the winter as far as cold was concerned. The preliminary results from these trials suggested that the winter sowing might be followed by a yield advantage of the order of 50 or even 100% from the longer growing season, better moisture supply, etc. However, following our first steps towards establishing the station at Aleppo, in the hazy twilight period between the end of the ALAD and the beginning of ICARDA, nurseries of chickpea were sown on the University of Aleppo farm by the courtesy of the Dean and his staff at Muslimieh and there it became obvious why there was preference for spring sowing. The winter sown crops were very severely attacked by ascochyta blight and it was evident that a heavy attack of ascochyta could destroy the crop. The winter sowing for that reason was a risk which a farmer was rightly not prepared to take. This triggered off a desire for research on the control of ascochyta blight and a fair amount of work with fungicides was carried out. All that could be shown was that they could work, but were not the real answer. What was needed was the genetic resistance if the winter planting of chickpeas was to become a reality on farmers' fields. And work began at once on identifying sources of resistance. I am glad to learn that to date several sources of resistance have been identified in the chickpea germplasm collections maintained at ICRISAT and ICARDA.

Several of the resistant genotypes have been tested in International Disease Screening Nurseries which began in 1978-79. And the resistance sources have been more precisely identified which stand up across a number of the locations. There are, however, growing fears that a number of strains or pathotypes of this disease organism may exist and this will have to be taken into account. While you may appear to have got resistance across the locations, you have got to be quite sure that you are coping up with all the strains of the disease that may be there. So on a fairly sound research base,the genetic improvement of chickpeas with respect to ascochyta blight is now well under way here. And this work has gone from the research stations to the farmers' fields.

In 1979-80 the first trials of winter sowing of chickpeas were conducted on farmers fields here in Syria. This followed a specific request from His Excellency the Minister of Agriculture and Agrarian Reform of Syrian Arab Republic that there should be an expanded effort on winter chickpeas in Syria. He was impressed by information then to hand of the big yield advantage that could be gained by such winter planting and we were strongly pressed to move in this direction. These trials in 1979-80 were carried out in cooperation with the Department of Scientific Agricultural Research of the Syrian Ministry of Agriculture. The results of these first trials were, to say the least of it, very encouraging indeed. Across a total of 18 locations in Syria, the variety called ILC 482, a resistant type, yielded an average of nearly 1900 kg/ha on winter planting compared with only 900 kg/ha on spring planting, giving rather more than 100 % yield increase not just in one spot but on a broad brush approach across the area. The trials have continued in 1980-81 in collaboration with the Department of Scientific Agricultural Research, and it is hoped that, providing the results confirm those of the year before, a full-blooded effort will be made to extend this new technology to the farming community. And there is no reason why it should not be done. This season on-farm trials of winter chickpeas are also being conducted in Jordan and Lebanon by the respective national programs.

International Yield Trials have also been carried out for winter planting. These trials started in 1979-80 and the material went to 15 locations in nine different countries. The results fed back to us have indicated again a very large yield potential from winter sowing, not invariably but in most of the countries, and yields in excess of 3000 kg/ha have been reported from several locations. The success of these International Yield Trials is indicated by the fact that 44 sets of seed for these trials were sent to 17 countries in 1980-81 and even this was no more than 80 % of the total demand. Sometimes we are accused of getting on to countries and insisting to take our trials. This is not the case, as far as these trials are concerned. The demand exceeds our capacity to supply it. While we are ashamed that we could not meet all the requirement but we are very pleased for the interest being shown.

So, Mr. Chairman in view of the probable widespread applicability of winter chickpeas throughout the ICARDA region, and the consequent possibilities for dramatic improvement in yield at the farm level we felt here that the time was ripe for holding a workshop of this nature. We believe there is a dramatic breakthrough in chickpea production. A big step forward awaits us to be made, not rashly or impulsively but on the basis of sound application of reason and planning of further research. We hope that during the workshop past research will be reviewed in depth and the priorities for our further research as also the strategies for extending the new technology to farmers will be collectively decided. Those of us who are older in this game know that all too often research centres and stations dream up a new technology to find that it does not necessarily latch

in with farmers'plans and proposals or indeed with their expectations. We are very conscious that we go no faster than within the limits that farmers are prepared to accept. We do need to consider the strategies for extending this technology to the farmers in the region. It is our hope that these will also be discussed.

Mr. Chairman, I think this is about all I want to say on this occasion. You have a very interesting program for the rest of the workshop ahead of you. I feel I would be multiplying words and extending time unnecessarily if I prolong my remarks and if I may leave it there, I would like, in closing, to echo your welcome to the delegates here and to wish them a very successful workshop.

Thank you very much indeed.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Prospects and Potential of Winter Sowing of Chickpeas in the Mediterranean Region

G.C. HAWTIN and K.B. SINGH
Program Leader, Food Legume Improvement Program, ICARDA, Aleppo, Syria;
Chickpea Breeder (ICRISAT), ICARDA, Aleppo, respectively.
A joint contribution from ICARDA and ICRISAT centers.

Chickpea is the fifth most important grain legume crop after soya beans, grounduts, dry beans and dry peas. The major area of production is in the Indian subcontinent (Bangladesh, Burma, India and Pakistan) where small, angular, dark-seeded chickpeas, known as desi types, predominate. In this region, and also in Ethiopia, chickpeas are normally sown at the end of the summer rains and are raised on residual soil moisture. The chickpeas grown in the Mediterranean basin, which comprises the countries of southern Europe, western Asia and northern Africa, usually have larger, more rounded, buff- coloured seeds and are referred to as kabuli types. They are normally planted in the spring (February – May) and are largely raised on residual soil moisture, since in the typical Mediterranean environment rainfall occurs almost exclusively in winter.

Thus, with a few exceptions, for example the irrigated crop in the Nile Valley of Egypt and Sudan, chickpeas are almost universally raised under a diminishing soil moisture supply, with rarely any significant precipitation during the growing season. Limited available moisture may restrict yields, and delayed planting can also result in the reproductive phase of growth (a particularly sensitive stage of phenological development) coinciding with increasing, and possibly limiting temperatures.

In the Mediterranean region the two other main food legume crops, faba beans (*Vicia faba*) and lentils (*Lens culinaris*), are normally planted in the autumn or early winter, at least in the lower or medium elevation areas. Germination and plant establishment take place before the onset of the coldest weather and vegetative growth occurs rapidly when temperatures rise again in the spring. By contrast, chickpeas are normally sown only when the land becomes available in early spring and thus the entire plant development takes place under conditions of increasing temperature, daylength and aridity. Lentils or faba beans mature in

about 130 to over 200 days, whereas chickpeas in the same area usually mature in less than 120 days.

Research on Winter Chickpeas at ICARDA

In the 1974/75 season, the Arid Lands Agricultural Development Program (the forerunner of ICARDA) took up investigations on whether or not chickpeas could survive the winter in the Mediterranean region, and how that affected the plant growth, development and yield. One hundred and ninety-two genotypes were planted in the autumn at an altitude of about 1000 m at the Kfardan research station in the Bekaa Valley of Lebanon.

All entries survived the winter, in spite of the subzero temperatures on several occasions. This suggested that, contrary to the opinion of many farmers in the area, chickpeas have adequate cold tolerance to survive the winter, at least at low-medium elevations. Subsequent studies at ICARDA have confirmed this, and it appears possible to develop cultivars with tolerance to even colder winter. In the 1979/80 season over 3000 germplasm accessions were evaluated near Ankara and Erzurum on the high Anatolian Plateau of Turkey. Several lines survived the winter at both locations. An unusually late frost occurred at ICARDA's farm at Tel Hadya near Aleppo on 1 April 1981. This coincided with the early flowering stage of the winter crop. Though many of the lines were severely damaged, some genotypes were identified that were comparatively resistant to cold.

The possibility that winter chickpeas would make better use of the available moisture and could be harvested earlier was pointed out by Hawtin (1975). However, the first field evidence of substantial yield increases from this practice was obtained in 1977. A yield trial was planted both in the autumn of 1976 and in the spring of 1977 by ICARDA at the University of Aleppo research farm at Muslimieh. In the autumn-sown trial, all entries except an exotic desi type survived the winter. Then with the onset of spring, ascochyta blight began to appear and subsequently destroyed almost all entries. However, one entry (NEC 2305) showed a moderate level of resistance to the disease and produced a yield of over 3000 kg/ha. Although the spring-sown trial escaped the disease, yields were substantially lower; NEC 2305 produced only 950 kg/ha. It was apparent that ascochyta blight, rather than freezing temperatures, is the main reason why farmers plant the crop in spring.

In view of the considerable yield advantage which had been obtained, it was decided to mount a major research effort to study the various aspects of winter sowing and in particular methods of controlling ascochyta blight. During the 1977/78 season the research received a considerable boost following an agreement between the International Crops Research Institute for the Semi-Arid

Tropics (ICRISAT) and ICARDA to combine their respective chickpea programs. ICRISAT posted a chickpea breeder to ICARDA in the 1977/78 season to identify some promising sources of resistance to ascochyta blight in the germplasm collection. Although not all lines identified that season maintained their resistance under greater disease pressure the following season, several lines did hold up and have been used widely in the breeding program since then.

In the following season, approximately 400 lines were tested during winter, and some of them both in winter and spring. The results confirmed that winter-sown chickpeas are capable of producing over 3000 kg/ha and can successfully grow even with as little as 250 mm of rainfall, compared to about 350 mm normally required for the spring-sown crop.

Since that time, special attention has been focused on the development of disease screening techniques, identification and wide-spread evaluation of sources of resistance, incorporation of resistance into a range of genetic backgrounds and studies on the nature of inheritance of resistance. Epidemiological studies on ascochyta blight have been conducted, and research on the use of fungicides, particularly as a seed dressing, is under way. Agronomy trials are aimed at identifying optimum cultural practices for the winter crop and include research on inoculation with effective strains of *Rhizobia*. Aspects of plant physiology, pest problems, weed control, economics and the role of winter chickpeas in crop rotations are all now being investigated at ICARDA.

Resistance to Ascochyta Blight

As indicated earlier, the major hazard faced by winter chickpeas is ascochyta blight. A severe epidemic of this disease can totally destroy the crop. Even in spring-planted chickpeas, ascochyta blight is regarded as one of the main disease problems throughout most of the Mediterranean region, including Spain (Cubero 1975), West Asia (Hanounik 1979) and North Africa (Djerbi *et al.* 1979). It can be especially severe if late rains are received.

Winter chickpeas are thus only possible if adequate control of the disease can be achieved. Although fungicides have been effective in some trials, in others the level of control has been inadequate. In the 1978/79 season severe damage occurred on one field at Tal Hadya in spite of fungicide (Diathane M45) application on 12 separate occasions during the season. Thus the only reliable method of disease control available to date is the use of resistant cultivars.

The relationship between disease resistance and yield was evaluated for 70 lines in the 1979/80 season at Tel Hadya (Table 1). The resistant lines had a mean yield of over 2000 kg/ha, which was over twice the mean yield of the susceptible lines. The highly susceptible lines failed to produce any seed at all.

By 1980 over 9000 germplasm accessions and segregating populations had been screened at ICARDA. Twenty-two kabuli and 32 desi germplasm acces-

Table 1
Mean yield and range of 70 chickpea lines classified according to their reaction to ascochyta blight, Tel Hadya, 1979/80 season.

Disease reaction category	No. of lines	Mean yield (kg/ha)	Yield range (kg/ha)
Resistant	11	2271	2739 – 1816
Moderately resistant	6	1588	2304 – 1278
Susceptible	45	1003	1247 – 454
Highly susceptible	8	0	–

sions were found to be resistant. Most of these are now being widely used in the breeding program.

The Chickpea International Ascochyta Blight Nursery (CIABN) was started in 1978 to evaluate the sources of resistance identified at Tel Hadya in other endemic areas throughout the region. The data returned from five countries over three years indicate that three of the lines were consistently rated as resistant in all trials. Other lines reacted differentially between the various sites, probably due to the presence of different pathotypes.

The possibility of new pathotypes overcoming the resistance of a particular chickpea cultivar is the sword of Damocles hanging over the breeders' (and even more so the farmers') heads. The probability of such a breakdown of resistance has not yet been clearly established but breeding strategies at ICARDA are increasingly being directed towards the development of stable resistance.

On-farm Trials

Many of the sources of resistance identified so far have been in undesirable types from an agronomic or seed quality standpoint. However, a few were considered to be promising in all respects. Following a request from His Excellency the Minister of Agriculture in Syria it was agreed that these should be widely tested throughout the country. Accordingly, 18 uniform trials were conducted in the 1979/80 cropping season in collaboration with the Department of Agricultural Research and Extension of the Syrian Ministry of Agriculture. Three resistant cultivars, and a local susceptible landrace were sown in the winter. A high-yielding line and the local landrace were sown at the normal time in early spring. The trial was planted both on research stations and on farmers' fields.

Although the local landrace planted in winter performed well in most of the

sites where the disease was not severe, it failed completely at locations where epiphytotics occurred. The resistant cultivar ILC 482, however, performed consistantly well at all sites (Table 2). The mean yield of ILC 482 was 113% higher than that of the Syrian landrace planted in spring. This comparison may have been exaggerated due to the presence of ascochyta blight in some of the spring-planted crops; which in turn may have been enhanced by a large inoculum load originating from adjacent heavily attacked winter-sown plots. However, the mean yield of ILC 482 was still nearly double that of the Syrian landrace considering only those sites where the disease was rated 3 or less in spring. This trial is being repeated this season on about 30 sites in Syria and the cultivar ILC 482 is also being evaluated in on-farm trials in Jordan and Lebanon.

Table 2
Seed yield and disease rating of cultivars sown during winter and spring in farmers' fields and Experiment Stations in Syria, 1979/80.

	WINTER				SPRING	
	ILC482		Syr. Local		Syr. Local	
Location	Y[1]	DR[2]	Y	DR	Y	DR
Izra	1666	ND	1444	ND	793	ND
Gelline	1076	1	707	7	666	ND
Hama[3]	3427	ND	3093	ND	3190	ND
A village near Hama	1831	ND	1740	ND	816	ND
Homs	2833	1	1056	ND	1555	3
A village near Homs	2222	ND	1111	ND	1389	ND
Boustan El-Basha	1667	ND	0	9	0	9
Azes	836	2	501	2	401	3
Atareb	2110	1	701	7	477	3
Derkak	712	1	31	9	5	9
Ebben	1039	1	863	3	791	1
Kawkaba	1576	1	809	5	1674	1
Mohambel	1781	2	281	3	264	2
Maret Masrin	1417	1	706	5	1173	5
Breda	2481	ND	146	ND	104	ND
Jinderis	2464	3	0	9	0	9
Kararantoon	1357	ND	1638	ND	1658	ND
Tel Hadya	1971	3	0	9	605	5
Mean	1839		824		865	

1. Y = yield (kg/ha).
2. DR = disease rating: 1, no disease; 9, complete kill; ND, no data.
3. The trial at Hama was irrigated and protected by fungicide.

International Yield Trials

A 10-entry trial was distributed to cooperators in 1979, for planting in the winter season. The results from nine locations are shown in Table 3. The cultivar ILC 482 performed well at most of the sites, whereas the local check cultivar, supplied by the cooperators, was ranked in the lower half of the entries in seven of the sites. Trial mean yields in the order of 3000 kg/ha were recorded in Lebanon, Algeria and Morocco, indicating a very high yield potential from winter sowing in these countries. The data from Lattaquieh and Gelline in Syria, and Larissa in Greece also revealed a yield potential in excess of 2000 kg/ha for certain of the best entries.

This trial was enlarged to 20 entries in the 1980/81 season and has been distributed to a total of 44 locations in 17 countries. Even the distribution of this number of trials met only 80% of the requests, and provides a good indication of the amount of interest being shown in winter planting by cooperators in the region.

Disadvantages of Winter Chickpeas

In spite of the many advantages of winter over spring sowing (e.g., better plant establishment and nodulation, less damage from birds and insects and the possibility of extending the crop into drier regions) a number of problems still exist.

As stressed above, ascochyta blight contol is of paramount importance. If this is to be achieved through resistant cultivars it is essential that seed production is handled carefully. No mixtures of resistant and susceptible cultivars can be tolerated in seed production programs and it is essential that no mistake be made with respect to cultivar identification. It is also highly desirable that any resistant cultivar released to farmers be identifiable from its seed and plant characteristics.

The normal spring-planted crop is comparatively weed-free. The winter rains enable most of the weed seeds to germinate, but these are destroyed by spring cultivation prior to planting. It may still be possible to achieve good control by waiting for the first rains to germinate the weeds in the autumn and a cultivation at that time can greatly reduce the problem, as is the practice in other winter-sown legumes such as lentils. However, hand weeding in spring is normally necessary in lentils and this is likely to be the case in chickpeas too. A number of herbicides that can be used selectively in winter chickpeas have been identified and many farmers may find it economic to use such chemical weed control measures.

Chickpeas are sensitive to waterlogging and it is essential that fields chosen for winter sowing are free-draining and do not allow any standing water.

A problem which has been frequently encountered in conducting trials on

Table 3

Yield and rank of entries in the Chickpea International Yield Trial-Winter.

	Lebanon		Syria						Jordan		Algeria		Morocco		Cyprus		Greece			
	Terbol		Tel Hadya		Gelline		Lattaquieh		Univ		Khroub						Larissa		Mean	
ILC	Y[1]	R[2]	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
184	3342	4	362	5	1743	3	2476	5	1071	9	3578	3	3583	2	303	9	2503	2	2107	3
190	2738	6	231	6	1350	9	2964	1	1381	3	3987	2	3000	8	379	5	2471	3	2056	5
195	2362	9	1607	3	1884	2	2571	4	1113	7	2977	7	3000	8	319	8	2440	4	2030	6
202	2094	10	1313	4	1626	5	2321	6	1106	8	2992	6	3042	7	326	7	1820	7	1849	7
215	2552	8	178	7	1375	8	1481	8	1268	5	2609	8	3062	6	401	4	1755	9	1631	8
249	2769	5	125	9	1414	7	2690	3	1401	2	4286	1	3917	1	500	1	2206	5	2145	2
482	3352	3	1894	1	2163	1	2810	2	1440	1	3469	4	3275	5	483	2	2646	1	2392	1
1929	3672	2	0	10	1308	10	0	10	1141	6	281	10	1521	10	460	3	2031	6	1488	10
3279	3279	1	1796	2	1735	4	1750	7	1060	10	3094	5	3417	4	288	10	1797	8	2101	4
Loc. check	2734	7	131	8	1451	6	1333	9	1298	4	2010	9	3500	3	346	6	1719	10	1614	9
Location mean	2959		873		1605		2040		1328		2928		3132		380		2139		1941	
CV(%)	30.3		13.2		13.0				5.7		15.1				28.0		21.2			
LSD (5%)	1538.0		168.6		259.0				111.2		642.7				154.8		656.7			

1. Y = yield (kg/ha).
2. R = rank.

small plots on farmers' fields is very heavy damage from small mammals such as moles, voles and rabbits. The extent to which this is likely to be a major problem on large-scale field plantings is yet to be determined. It is expected, however, that considerably less damage would be caused.

Although it is possible to successfully grow winter chickpeas under much lower rainfall situations than is possible for the spring-sown crop, the extension of the crop into non-conventional chickpea areas may have to be accompanied by inoculation with *Rhizobium* if nodulation is to be adequate to meet the nitrogen needs of the crop.

Limitations of time in the winter planting season may prevent the crop being sown at that time. Farmers frequently give priority to planting cereals, following which the season may be too advanced, and the soil too wet, to allow access before early spring.

Although ascochyta blight has been identified as the major problem, if winter sowing is practised on a large scale, new diseases and pests may appear. Diseases that favor cool and wet conditions, such as *Botrytis* grey mould and *Stemphylium*, may become important on winter chickpeas in the future. The parasitic angiosperm, *Orobanche crenata* has already been observed on winter chickpeas; it is rarely seen on the spring-sown crop. It is possible that new strains which are virulent on chickpeas might build up in the future. The pest and disease situation will therefore have to be monitored closely.

Conclusions

In the South Europe, North Africa and West Asia region, chickpeas were grown on nearly 600,000 hectares in 1979 (Table 4). Mean yields in excess of 1000 kg/ha were recorded only in Lebanon, Turkey, Italy, Iran, Morocco and Bulgaria. If the experience in Syria to date can be repeated throughout the region, it might not be unreasonable to expect total production to increase from its present level of just over 500,000 tonnes to almost one million tonnes. Such a target might even be exceeded if areas which are currently considered too dry for chickpeas (down to the 250 mm isohyet) are brought into cultivation of the winter-sown crop.

If this is to come about, much work remains to be done. The currently available sources of resistance have to be closely monitored and efforts to develop cultivars with potentially more stable resistance should be increased. Seed production and distribution must be efficient and reliable, and inoculants may have to be made available to farmers in the drier regions. A close watch will have to be kept for new pest and disease problems which may arise. In each country, different problems may be encountered which may result from socioeconomic as well as biological or environmental factors. Optimum cultural practices for

Table 4
Production and yield of chickpeas in countries of North Africa, West Asia and South Europe during 1979[a].

Country	Area (x 1000 ha)	Production (x 1000 tonnes)	Yield (kg/ha)
World	10364	7405	714
North Africa			
Algeria	42	23	548
Morocco	62	64	1030
Tunisia	37	20	545
West Asia			
Cyprus	1	1	818
Iran	39	41	1049
Iraq	14	9	597
Jordan	1	1	385
Lebanon	1	2	1818
Syria	47	33	714
Turkey	180	226	1256
Europe			
Bulgaria	1	1	1000
Greece	10	9	900
Italy	14	17	1213
Portugal	39	12	320
Spain	103	64	621
Yugoslavia	1	1	600

a. Source: FAO Production Yearbook, Vol 33, 1979.

raising the winter crop will have to be determined in each agroecological zone within a country. Finally major campaigns will have to be mounted to demonstrate the feasibility and advantages of winter planting to the farmers of the region.

References

CUBERO, J.I. 1975. The research on the chickpea (*Cicer arietinum*) in Spain. Pages 117-122 *in* Proceedings of the International Workshop on Grain Legumes. ICRISAT, Patancheru, A.P., India.

DJERBI, M., MALAIKI, A., and BOUSLAMA, M . 1979. Food legume diseases in North Africa, Pages 103-105 *in* Food Legume Improvement and Development. Pub. IDRC-126e, Ottawa, Canada.

ESER, D. 1979. Grain legume production in Turkey. Pages 71-74 *in* Food Legume Improvement and Development. Pub. IDRC-126e, Ottawa, Canada.

HANOUNIK, S.B. 1979. Diseases of major food legume crops in Syria. Pages 98-102 *in* Food Legume Improvement and Development. Pub. IDRC-126e, Ottawa, Canada.
HAWTIN, G.C. 1975. The status of chickpea research in the Middle East. Pages 109-114 *in* Proceedings of the International Workshop on Grain Legumes. ICRISAT, Patancheru, A.P., India.

Discussion

M. Aslam
What are the planting and harvesting time for spring and winter planted chickpeas and their relation with rainfall?

G.C. Hawtin
Planting of winter chickpeas in Syria depends on when the rains start; any time from October to December. Spring planting takes place towards the end of the rainy season in late February or March.

M. Aslam
Do you experience any mortality from wilt at crop maturity time due to shortage of soil moisture?

K.B. Singh
Wilt and root rot disease complex makes comparatively more damage to spring sown crop than winter sown crop. However, the extent of damage by these diseases is not serious at the moment.

M. Kamal
Table 2 shows that the yield in winter planting even with local material can be upto 1700 kg/ha. Does that mean that we can avoid Ascochyta blight by planting at optimum date in certain location even by using susceptible cultivar?

G.C. Hawtin
Yields can be high on susceptible materials if there is no disease. When disease is severe, however, there can be zero yield. Delaying the planting date reduces the risk of disease, but the yield potential is also considerably lower.

A. Telaye
There are climatological differences of winter season in between ICARDA's working mandatory regions and Ethiopia. How could one reconcile the differences in integrating research activities?

G.C. Hawtin
In Ethiopia ascochyta blight has been reported to be a problem. Normally the crop is planted there, as here, at the end of the rainy season. Earlier planting during the summer rains in Ethiopia is analogous to winter planting, and it too may result in better use of available moisture.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Second Session: Ascochyta Blight

A Review of Ascochyta Blight of Chickpea (*Cicer arietinum* L.)

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Chickpea (*Cicer arietinum* L.) is an important grain legume crop of dryland agriculture in Asia, Africa and Central and South America. The total cultivated area of chickpea in the world is about 10.4 million hectares and annual production is about 6.8 million tonnes (FAO 1978). The average yields per hectare are estimated to be around 700 kg. Chickpea is known by other names such as Bengal gram, gram, Egyptian pea, Spanish pea, Chestnut bean (all English), pois chiche (French), chana (Hindi), homos (Arabic), grao-de-bico (Portuguese), garbanzo or garavance (Spanish), etc.

Ascochyta blight is considered to be one of the most important diseases of chickpea. Severe epidemics of this disease have been reported from many chickpea-growing countries The very fact that the present workshop deals in a major way with ascochyta blight bears testimony to its international importance. Since the objective of the workshop is to ascertain the present status of knowledge and to identify high priority areas of research for the immediate future, a review of the available literature on the ascochyta blight of chickpea is presented in this paper.

Historical

Ascochyta rabiei (Pass.) Lab., the causal fungus of the blight, was first named *Zythia rabiei* by Passerini in 1867 on the basis of unicellular and hyaline pycni-

diospores (Khune and Kapoor 1980). According to Khune and Kapoor (1980), Passerini's diagnosis was either overlooked or not accepted by later workers. Comes in 1891 identified the fungus as *Ascochyta pisi* Lib. and Prillieux and Delacroix in 1893 named it *Phyllosticta cicerina* (Khune and Kapoor 1980). After studying Saccardo's material, Trotter in 1918 concluded that the fungus was not *Ascochyta pisi* but resembled *Phyllosticta* and later proposed the combination *P. rabiei* (Pass.) Trotter (Khune and Kapoor 1980). Gonzalez (1921) agreed with Trotter's proposal. Labrousse (1930) described the fungus as *Phyllosticta rabiei* because he saw no bicellular spores on the host, though a few were observed in culture. However, a year later Labrousse (1931) suggested that the fungus be called *Ascochyta rabiei* as it produced 2-4% single septate spores on artificially inoculated plants. Although taxonomists still differ in their opinion about the name, *Ascochyta rabiei* is the name accepted by the majority of workers. The disease has always been considered economically important. Perhaps the best documented account of blight epidemics exists for the former Punjab province of British India, a part of which is now in Pakistan, where the disease was first observed in 1911 (Butler 1918). Records of subsequent epidemic years have been reviewed by Kausar (1965).

Geographical Distribution

The disease has been reported from the following 26 countries: Algeria, Australia, Bangladesh, Bulgaria, Canada, Cyprus, Ethiopia, France, Greece, India, Iran, Iraq, Israel, Italy, Jordan, Lebanon, Mexico, Morocco, Pakistan, Romania, Spain, Syria, Tanzania, Tunisia, Turkey and the USSR (Nene 1980). The disease is more frequently observed in Algeria, Bulgaria, Cyprus, Greece, Iraq, Israel, Jordan, Lebanon, Morocco, Pakistan, Romania, Spain, Syria, Tunisia, Turkey and the U.S.S.R.

Losses

There are many reports of serious losses caused by ascochyta blight. A few examples will suffice. Labrousse (1930) reported that the disease was very destructive in Morocco in 1929. In what is now Pakistan, investigations on the disease were initiated in 1922 and it was found that annually 25-50% of the crop was destroyed (Sattar 1933). According to Kovachevski (1936b), 20-50% of the crop was lost annually in Bulgaria, while occasionally total loss occurred in certain fields. In the Dnepropetrovsk region of USSR, the blight was severe in 1956 "sometimes causing 100% loss" (Nemlienko and Lukashevich 1957). In Greece, 10-20% damage was reported during 1957-58 (Demetriades *et al.* 1959).

According to Puerta Romero (1964) the disease "causes great losses of chickpea wherever it is grown in Spain". In Pakistan about 70% of the crop was lost in 1979 and 1980 (personal communication from Dr. Bashir Ahmed Malik).

Anyone who has seen the disease in the field will readily agree on the potential of this disease to cause serious losses in chickpea. In fact, epidemics of the disease have been reported by several workers (Benlloch 1941; Biggs 1944; Kaiser 1972; Kausar 1965; Radulescu *et al.* 1971; Zalpoor 1963).

Symptoms

Several workers have described the symptoms of the disease as it occurs in different countries (Atanasoff and Kovacevski 1929; Benlloch and Del Canizo 1931; Labrousse 1930; Luthra and Bedi 1932). The descriptions are remarkably similar. All above-ground parts of the plant are attacked. On leaflets the lesions are round or elongated, bearing irregularly depressed brown dots, and are surrounded by a brownish red margin. On the green pods the lesions are usually circular with dark margins and have pycnidia arranged in concentric circles. Often the infected seeds carry lesions. On the stem and petiole, the lesions are brown, elongated (3-4 cm), bear black dots and often girdle the affected portion. When lesions girdle the stem, the portion above the point of attack rapidly dies. If the main stem is girdled at the collar region, the whole plant dies. As the disease advances, patches of diseased plants become prominent in the field and slowly spread, involving the entire field. Labrousse (1930) stated that "seeds do not appear to be attacked." This is certainly incorrect, and it is puzzling that he did not observe lesions on seeds. Recently, Haware and Nene (1981) described a blight caused by *Phoma medicaginis*. Symptoms of this blight resemble ascochyta blight symptoms, but pycnidia in concentric circles are not present in the case of phoma blight.

Pathogen

1. Taxonomy

Some taxonomic information has been given earlier in the historical section. Although a large number of workers accept *Ascochyta rabiei* as the name of the fungus, some workers do not agree. They prefer to use *Phyllosticta rabiei* (Luthra and Bedi 1932; Aujla 1960). Recently Khune and Kapoor (1980) suggested that the fungus be called *Phoma rabiei* (Pass.) on the basis of the presently accepted concept that *Phoma* contains about 5% bicelled pycnidiospores. The Commonwealth Mycological Institute, however, continues to call the fungus *Ascochyta rabiei*.

2. Reproduction

Asexual. The asexual or imperfect stage of the fungus is characterized by the production of the fruiting bodies (pycnidia) which produce spores (pycnidiospores). Pycnidia are visible as minute dots in the lesions produced on the host. Pycnidia are immersed, amphigenous, spherical to subglobose or depressed and generally vary in size from 65 to 245 u (Sattar 1934). Pycnidiospores (also called spores or conidia) are oval to oblong, straight or slightly bent at one or both ends, hyaline, occasionally bicelled, 8.2 to 10.0 x 4.2 to 4.5 μ. Kovachevski (1936a) reported the spore size to be 6.0 to 16.0 x 3.4 to 5.6 μ on host and 4.8 to 14.0 x 3.2 to 5.2 μ on an artificial medium.

Colonies of the fungus on artificial media (e.g., oat meal agar) are flat, submerged, with sparse mycelium, white at first and later turning dark and fumaceous. Bedi and Aujla (1970) reported that pycnidia developed best at pH 7.6 – 8.6 at 20°C on Richards' medium of double concentration. Besides oat meal agar, chickpea seed meal (4-8%) agar has been found to be a good medium for the growth of the fungus and pycnidial production (Kaiser 1973; Reddy and Nene 1979). Optimum temperature for growth, pycnidial production and spore germination has been found to be around 20°C (Bedi and Aujla 1970; Chauhan and Sinha 1973; Kaiser 1973; Maden *et al.* 1975; Zachos *et al.* 1963). Temperatures below 10°C and above 30°C have been found unfavourable to the fungus (Chauhan and Sinha 1973; Kaiser 1973; Luthra and Bedi 1932). Light affects growth of the fungus on artificial media. Kaiser (1973) reported that continuous light resulted in increased sporulation. Chauhan and Sinha (1973) reported reduced sporulation on infected plants in a glasshouse when continuous light was given. My own experience in ICRISAT supports Kaiser's findings. The incubation period between inoculation of plants and appearance of symptoms varies between 5 and 7 days depending on the temperatures provided (Chauhan and Sinha 1973; Zachos *et al.* 1963). It also varies with genotypes inoculated.

Sexual. Kovachevski (1936a) was the first worker who observed the sexual stage of the fungus (in Bulgaria) and named it *Mycosphaerella rabiei* Kovachevski. The fruiting bodies, perithecia, were found exclusively on chickpea refuse, especially the pods, that had overwintered in the field. They were dark brown or black, globose or applanate, with a hardly perceptible beak and ostiole and were 76 to 152 x 120 to 250 μ in size. The asci were cylindrical-clavate, more or less curved, pedicellate and 48 to 70 x 9 to 13.7 μ in size. The ascospores (8 per ascus) were monostichous, rarely distichous, ovoid, divided into two very unequal cells, strongly constricted at the septum and measured 12.5 to 19 x 6.7 to 7.6 μ. Subsequently, Gorlenko and Bushkova (1958) confirmed the presence of the perfect stage in the USSR, and Zachos *et al.* (1963) in Greece. Obviously, conditions in eastern Europe and western Asia are favorable for the production of

the perithecial stage. If a cold winter is a prerequisite for the production of perithecia, one may not observe these in agroclimatic regions represented in the Indian subcontinent where hot summers follow the chickpea season. It is well known that the presence of the perfect stage has a bearing on the production of new races.

3. Races

There have been very few studies on races. Luthra *et al.* (1939) and Arif and Jabbar (1965) did not find any evidence of the existence of races. A report from India (Anonymous 1963) stated that the cultivar C-12/34 lost its resistance probably due to a new race. Bedi and Aujla (1969) studied variation in the fungus isolates under controlled conditions. On the basis of symptomatology, manner of pycnidial formation on the host, and pathogenic behavior of 11 isolates, they concluded that several races exist in the state of Punjab in India. Vir and Grewal (1974b) identified two races (1 and 2) and one biotype of the race 2 using I-13, EC-26435, C-235, F-8 and V-138 cultivars as differentials. Recently Singh *et al.*, (1981) obtained indications of the existance of races through results obtained from the Chickpea International Ascochyta Blight Nursery. Intensified race studies to obtain a full picture of the race situation are needed if stable host resistance to ascochyta blight is to be achieved.

Epidemiology

1. Survival

The fact that there are so many reports of epidemics of this blight clearly indicates the existence of efficient mechanisms for the survival of the fungus from one season to another. Several workers have studied this aspect and reported that the fungus survives mainly in the diseased crop debris and in seeds from infected plants.

Crop Debris. The above-ground parts of the plants are infected and pycnidia are produced on these infected parts. Sattar (1933) could not determine the absolute importance of infected crop debris in fungus survival. Later, Luthra *et al.* (1935) considered infected debris to be an important source of primary infection in the following season because they found that the fungus survived for 2 years in infected tissues. However, they pointed out that the fungus will not survive if the infected debris is buried in moist soil at only 5 cm depth. Kaiser (1973) carried out systematic studies and confirmed that the fungus survived for over 2 years in naturally infected tissues at 10-35°C and 0.3% relative humidity at the soil

surface. However, the fungus lost its viability rapidly at 65-100% relative humidity and at soil depth of 10-40 cm.

This aspect of survival needs further attention. The fungus apparently survives in debris if conditions are dry and if the debris lies close to the soil surface. Which are those geographical regions where the climate between two chickpea season is dry? In such areas this particular mode of survival will be important. On the other hand, in countries such as India, infected crop debris should be of no importance because the chickpea season is followed by a monsoon season and the wetness of soil should not permit fungus survival in crop debris. However, does this actually happen in nature in India? We have no definite answer as yet.

Some interesting work on this aspect has been done in Pakistan by Kausar (1965). He studied the influence of winter rainfall during the chickpea-growing season (October to April) and of the preceding summer rainfall (May to September) on the development of epidemics. He studied correlations between the incidence of blight (percentage of crop area failed due to blight in Campbellpur subdistrict) and winter rainfall during the chickpea-growing season (October to April) and the preceding summer rainfall (May to September) in respect of the years 1906-1941. These studies revealed that years of high chickpea season rainfall coincided with a high incidence of blight. The incidence of blight was more than 50% during 15 years that received on an average more than 150 mm of rainfall. More than 150 mm rainfall was received in 26 years out of 35 and the incidence of blight was more than 10% during the 27 years periods. In another analysis it was found that chickpea seasons with low incidence of blight were followed by a summer of high rainfall. The correlation, however, was nonsignificant.

Seed. A good deal of research work has been done on the survival of the fungus through seed. Luthra and Bedi (1932) were probably the first to demonstrate the seed-borne nature of the pathogen. They showed that the seed coat and cotyledons of infected seeds contained mycelium and that the infected-seed weight was less than healthy-seed weight. Halfon-Meiri (1970) confirmed the presence of the fungus in the seed coat and cotyledons, and of pycnidia in lesions. Sattar (1933) demonstrated the surface contamination of seed with fungus spores and their role in causing infection. He found that 50% of such spores survived on seed for 5 months at 25-30°C, but only 5% of spores survived for 5 months at 35°C. Zachos (1952), Gobelez (1956) and Khachatryan (1961) also confirmed the seed-borne nature of the pathogen.

Lukashevich (1958b) showed that the fungus can behave as a saprophyte and spread to noninfected tissues if the harvested material is stored for some time before threshing. He found 1.5 to 2-fold increases in seed infection during prethreshing storage. Maden *et al.* (1975) carried out a detailed study in Denmark on the seed samples received from Turkey. They found that 70% of this

seed from Central Anatolia was infected by *A. rabiei*. The inoculum occurred as spore contamination and mycelium in the seed coat alone or in the seed coat and embryo. Pycnidia were observed only in the seed coat of seeds having deep lesions. Whole-mount preparations and microtome sections showed that the inter- and intra-cellular mycelium was localized in lesions. Pycnidia were subepidermal and contained mature spores. Pycnidiospores obtained from the seed surface and pycnidia from 14-month old seed stored at 3° ±1°C, showed 33% germination. They established that both superficial and deep infections were equally potent in the transmission of the disease.

All these studies considered together clearly establish the role of seed in perpetuating the fungus from one season to the next.

2. Spread

The spread of the disease has been attributed to the pycnidiospores produced at the foci of primary infection, either through crop debris or infected seed. Most workers seem to agree that temperatures of 20-25°C are best for the build up of infection (Askerov 1968; Chauhan and Sinha 1973; Zachos *et al.* 1963). Chauhan and Sinha (1973) in a glasshouse study found 85-98% relative humidity and 20°C temperature to be most favorable, provided this humidity was maintained for at least 84 hours. They found the incubation period under these conditions to be 6 days. Khachatryan (1962), working in Armenia, reported over 60% relative humidity, with 350-400 mm rain during summer and an average daily temperature of not less than 15°C, to be congenial for the incidence and spread of the disease. According to Luthra *et al.* (1935) the primary infection foci in a field are limited and isolated, but windy and wet conditions help in the rapid spread of the disease. They suggested that infected debris, broken off from brittle diseased plants, could be transported by wind for several hundred meters. Disease spreads rapidly if wet and windy conditions occur in February and March when temperatures are around 22-26°C.

Everyone knows that this disease spreads rapidly, sometimes too rapidly, and causes epidemics in extensive areas. Existing information on the epidemiology does not fully explain the occurrence of widespread epidemics of this disease at different times in different years and in some years but not in others, in spite of favorable weather.

3. Host Range

Most workers have reported *Cicer* spp. to be the only hosts of *A. rabiei* (Bondartzeva- Monteverde and Vassilievsky 1940; Gorlenko and Bushkova 1958; Sprague 1930). However, Kaiser (1973) reported that the fungus could infect cowpea (*Vigna sinensis*) and bean (*Phaseolus vulgaris*) when inoculated artificially. He

observed small reddish brown spots on the stems, petioles and leaves of cowpea and on the leaves of bean, but the lesions did not increase in size. However, Sprague (1930) found no symptoms on *Phaseolus vulgaris* when inoculated artificially. Kaiser's finding is very interesting and needs to be confirmed. Information on other hosts of *A. rabiei*, if any, is lacking and research efforts in this direction need to be intensified.

Control

Measures to control this disease have been sought ever since it was first described. Measures that have been claimed to be effective are (a) utilizing host resistance, (b) adopting cultural control practices including sanitation, and (c) using chemicals to treat seeds and for foliar application. Literature on these aspects is briefly reviewed below.

1. Host Resistance

This aspect is discussed in greater depth in another paper in this workshop. Many reports on the identification of resistance can be seen in the literature.

Screening Techniques. Labrousse (1931) was perhaps the first scientist who made an effort to identify resistance through artificial inoculations. He scattered infected tissues on test plants and carried out repeated sprinklings with an aqueous suspension of spores. Luthra *et al.* (1938) repeated what Labrousse (1931) had done except that they used infected debris from the previous year to scatter on the test plants. Sattar (1933) had earlier suggested that the best time to carry out inoculations was when plants were flowering and podding. Sattar and Hafiz (1951) suggested broadcasting small bits of blighted plants on test plants after ensuring that the infected debris contained viable pycnidiospores. According to these workers, infection occurred after rain even if it were received months after inoculation. They claimed the method to be as effective as that in which aqueous suspensions of spores were applied. Vedysheva (1966) suggested spreading infected debris over soil both in autumn and spring. Taking a clue from the methods described above, Reddy *et al.* (1980) worked out an efficient field screening procedure. This involved (a) planting a row of susceptible line after every 2-4 test rows, to serve as an infector row, (b) spraying plants with a spore suspension prepared from diseased plants, (c) scattering infected debris collected in the previous season, and (d) maintaining high humidity through sprinkler irrigation.

Reddy and Nene (1979) used a glasshouse procedure for screening germplasm. This involved the use of an Isolation Plant Propagator (Burkard Manufac-

turing Co. Ltd., Rickmansworth, Herts, England). Ten seedlings of each germplasm line were grown in one pot. Two-week old seedlings were inoculated by spraying them with an aqeuous suspension of spores (20,000 spores/ml). Humidity was maintained by covering the plants with plastic covers for 10 days. This method proved very useful for confirming field results.

Disease Rating Scales. Vir and Grewal (1974b) suggested a 5-point scale for use in pot screenings as follows:

0 = No infections;
1 = A few minute localized lesions on stem and/or up to 5% foliage infection;
2 = Stem lesions 2-6 mm long which may girdle the stem and/or 5-25% foliage infection;
3 = Stem lesions bigger than 6 mm and girdling the stem and/or 25-75% foliage infection;
4 = All young shoots and leaves killed.

They (Grewal and Vir 1974) also suggested that the same scale be used in field screening.

Morall and McKenzie (1974) developed a 6-point scale for use in the field, as follows:

0 = No lesions visible on any plant in the plot;
1 = A few scattered lesions on the plants, usually found only after careful searching;
2 = Lesions common and readily observed on plants, but defoliation and damage not great, or in only one or two patches in plot;
3 = Lesions very common and damaging, severity intermediate between 2 and 4;
4 = All plants in plot with extensive lesions, defoliation and dying branches; but few, if any, plants completely killed;
5 = All plants, or all but parts of a few, completely killed.

Singh *et al.* (1981) extended the scale to 9 points having five defined categories of severity, as follows:

1 = No disease visible on any plant (highly resistant);
3 = Lesions visible on less than 10% of the plants, no stem girdling (resistant);
5 = Lesions visible on up to 25% of the plants, stem girdling on less than 10% of the plants but little damage (tolerant);
7 = Lesions present on most plants, stem girdling on less than 50% of the plants, resulting in the death of a few plants and causing considerable damage (susceptible);
9 = Lesions profuse on all plants, stem girdling present on more than 50% of the plants and death of most plants (highly susceptible).

This scale has been used by them for evaluating materials in a large-scale breeding program.

Reddy and Nene (1979) developed a 9-point scale for greenhouse screening in a propagator, as follows:

1 = No lesions;
2 = Lesions on some plants, usually not visible;
3 = A few scattered lesions, usually seen only after careful examination;
4 = Lesions and defoliation on some plants, not damaging;
5 = Lesions common and easily observed on all plants but defoliation/damage not great;
6 = Lesions and defoliation common, few plants killed;
7 = Lesions very common and damaging, 25% of the plants killed;
8 = All plants with extensive lesions causing defoliation and the drying of branches, 50% of the plants killed;
9 = Lesions extensive on all plants, defoliation and drying of branches, more than 75% of the plants killed.

Each of these rating scales has merit; however, there is a need to further simplify the rating scale and adopt a uniform scale for use by all research workers.

Sources of Resistance. Many reports on identification of resistance to ascochyta blight have appeared in the literature during the last 50 years. Many of these reports were based on observations made during natural epidemics while several were based on artificial inoculation tests in the field or in greenhouses. The majority of the reports are from the Indian subcontinent (Ahmad *et al.* 1949; Anonymous 1963; Aziz 1962; Bedi and Athwal 1962; Grewal and Vir 1974; Luthra *et al.* 1938; Padwick 1948). One of the cultivars that was identified as resistant was 4F32 (renamed F-8 by Luthra *et al.* 1938) which was traced to France. Subsequently, C-12/34 became a popular resistant cultivar and was obtained by crossing F-8 with Pb-7. Padwick (1948) noted that the resistance of F-8 remained effective. Around 1950, C-12/34 "lost" its resistance, but another resistant cultivar C-235 was developed and made available to farmers (Anonymous 1963). Aziz (1962) reported C-727 to be resistant, Grewal and Vir (1974) identified P-1528-1-1 (from Morocco) as immune and I-13 (from Israel) as resistant, and Singh (1978) reported resistance in Galben (from Rumania), E.C.-26414, -26435 and -26446. However, these sources of resistance have apparently not been used by breeders so far.

From regions other than the Indian subcontinent one finds fewer reports of resistance. Solel and Konstrinski (1964) identified the cultivar "Bulgarian" as immune and Kaiser (1972), working in Iran, found one black-seeded accession from Israel highly resistant to Iranian isolates of the fungus, but not to isolates from Pakistan. It is not certain if I-13 of Grewal and Vir (1974) is the same as the black-seeded accession of Kaiser (1972). Radkov (1978) reported from Bulgaria no. 180 and no. 307 to be resistant, high yielding and suitable for mechanical

cultivation. Also from Bulgaria, Ganeva and Matsov (1977) reported the cultivars Sovkhoznyi 14, Kubanskii 199, VIR-32, no. 222 (from the USSR) and Resusi 216 to be highly resistant.

With the inclusion of chickpea in the mandate of ICRISAT and subsequently in that of ICARDA, it has now become possible to carry out a systematic resistance breeding program on a wide scale and good progress has already been made. This work will be covered in another paper of this workshop.

It is important to identify good reliable sources of resistance, but what is more important is to use these sources to combine resistance with high yield.

Inheritance of Resistance. All the reports published so far (Eser 1976, Hafiz and Ashraf 1953; Vir *et al.* 1975) indicate that the resistance is governed by a single dominant gene. Thus incorporation of resistance into a high-yielding background should be fairly simple and easy.

Mechanism of Resistance. Sattar (1933) considered that more malic acid secreted by leaves at flowering/podding time favored infection. In contrast, however, Hafiz (1952) claimed that a resistant cultivar (F-8) secreted more malic acid than a susceptible cultivar (Pb-7) and that malic acid was inhibitory to spore germination and germtube development. Work carried out at ICRISAT (Reddy and Nene, unpublished) has not confirmed Hafiz's claim.

Hafiz (1952) found no difference in cuticle thickness between resistant and susceptible types, but found higher numbers of stomata in resistant types. Very little difference was found in the acidity of sap collected from resistant and susceptible types.

Ahmad *et al.* (1952) reported that resistant types (F-8 and F-10) were significantly taller, possessed a large number of hairs per unit area of stem and leaf, and had a smaller number of tertiary branches than the susceptible types (Pb-7, C-7).

In a series of papers Vir and Grewal (1974a; 1974c; 1975a; 1975b) compared biochemically a resistant cultivar (I-13) with a susceptible cultivar (Pb-7). They found that the resistant cultivar showed (a) higher peroxidase activity, (b) higher L-cystine content and (c) more phenolic content and higher catalase activity after inoculation. According to them, these biochemical differences should explain the resistance of I-13.

2. Cultural Practices

Sattar (1933) suggested the removal and destruction of dead plant debris, crop rotation, and deep-sowing of seed to prevent infected seeds from emerging, as methods to reduce the blight. Luthra *et al.* (1935), in addition to sanitation, suggested intercropping chickpea with wheat, barley, mustard (*Brassica campestris*), etc. to reduce disease spread in the crop season. Lukashevich (1958a)

suggested the application of potassium fertilizers to reduce disease severity. Reddy and Singh (1980) reported no effect of inter-row spacings on disease incidence. Adopting specific cultural practices will help, particularly when there is group action by all the farmers of a region.

3. Fungicides

Several reports on the use of chemicals for seed dressing and foliar spraying have appeared in the literature.

Seed Dressing. Sattar (1933) reported good control with the immersion of seed for 10 minutes in 0.5% copper sulphate, or the presoaking of seed in water at 20°C for 6 hours followed by immersion in hot water (53°C) for 15 minutes. Zachos (1951), however, found that hot water treatment adversely affected seed germination. He found that a 2-hour immersion of seed in malachite green (0.005%) or a 4-hour immersion in formalin eradicated seed-borne inoculum. Zachos *et al.* (1963) subsequently found that a 12- hour immersion in pimaracin (150 μ/ml) eradicated the inoculum completely. Various fungicides have been reported to reduce seed-borne inoculum. These include Granosan (Lukashevich 1958a), Phenthiuram (Ibragimov *et al.* 1966), thiram (Khachatryan 1961), benomyl (Kaiser *et al.* 1973) and Calixin M (Reddy 1980). Calixin M (11% tridemorph + 36% maneb) seems to eradicate the seed-borne inoculum completely, and this offers an excellent opportunity to treat the seed effectively. The need to find an effective and simple seed treatment cannot be overemphasized. On the one hand, such a treatment will be useful in controlling the disease and, on the other, it will facilitate free international movement of seed.

Foliar Sprays. Foliar applications of various fungicides have been reported to reduce disease spread significantly. These fungicides include Bordeaux mixture (Kovachevski 1936), wettable sulphur (Lukashevich 1958a), zineb (Solel and Kostrinski 1964), ferbam (Puerta Romero 1964), maneb (Retig and Tobolsky 1967), captan (Vir and Grewal 1974d) and Daconil (Se, Nycirek *et al.* 1977). Foliar sprays are generally ineffective under epidemic situations. Even under moderate disease situations, four to six sprays become necessary to significantly reduce the disease. The rapidity with which the disease spreads makes it very difficult to follow the application schedule. It is obvious that foliar application with presently available fungicides has limited scope at present.

Looking Ahead

It is proposed that, in the near future, the scientists working on this disease should address themselves to the following questions:

1. Sexual reproduction (perfect stage) occurs in *A. rabiei*. What are the conditions under which this stage is produced? What is its role, if any, in producing new races?
2. Is the available evidence on the existence of races of *A. rabiei* satisfactory? Should research work be intensified to get a complete global picture of the occurrence of races of this fungus?
3. To what extent does the diseased crop debris play a role in the perpetuation of *A. rabiei*? Does it play a role in some regions but not in others?
4. The role of infected seed in the perpetuation of *A. rabiei* is established beyond doubt. Is it important to determine the numerical threshold value (minimum percentage of seed infection) required for initiating an epidemic under favourable weather conditions? Is Calixin M seed dressing adequate to eradicate seed-borne inoculum? Is it likely to help in controlling the disease later in the season?
5. How does the disease spread? How far does the inoculum move? How is the occurrence explained of epidemics in large, geographically contiguous regions gions in certain years, but not in others?
6. Is *A. rabiei* specific only to the species of *Cicer*?
7. Is the efficacy of the resistance screening techniques satisfactory that have been developed so far? Are the presently used disease rating scales simple enough? Is there a need to develop a standard rating scale?
8. Is the performance satisfactory of "resistant" lines that have been identified so far?
9. Should a systemic fungicide be looked for that would control the disease with only one or two foliar sprays as a standby in case the resistance "breaks down"? As an example, such a fungicide is now available for controlling the downy mildews of several crops.
10. There is an increased interest now in growing chickpeas in non-traditional areas mainly because this crop requires low cultivation inputs. What steps should be taken to avoid introduction of *A. rabiei* into areas where it does not exist at present?

References

AHMAD, G.D., HAFIZ, A. and ASHRAF M 1952. Association of morphological characters with blight reaction. Pages 17-19 *in* Proc. 4th Pakistan Sci. Conf.

AHMAD, T., HASANAIN, S.Z. and SATTAR, A. 1949. Some popular methods of plant disease control in Pakistan. Agr. Pakistan 1: 18-22.

ANONYMOUS. 1963. Quarterly Report for October-December, 1962, of the Plant Protection Committee for the South East Asia and Pacific Region. Rome: FAO. 15 pp.

ARIF, A.G. and JABBAR, A. 1965. A study of physiologic specialisation in *Mycosphaerella rabiei* Kovaceveski *Ascochyta rabiei* (Pass.) Lab., the causal organism of gram blight. W. Pakist. J. Agr. Res. 3: 103-121.

ASKEROV, I.B. 1968. Ascochytosis of chickpea (in Russian). Zashch. Rast., Mosk. 13(3): 52-53.

ATANASOFF, D. and KOVACEVSKI, I.C. 1929. Parasitic fungi new for Bulgaria (in Russian). Bull. Soc. Bot. de Bulgarie, Sofia 3: 45-52.

AUJLA, S.S. 1960. Further studies on the blight disease of gram (*Cicer arietinum* L.) caused by *Phyllosticta rabiei* (Pass.) Trot., in the Punjab. M.Sc. thesis, Punjab Univ., Chandigarh, India.

AZIZ, M.A. 1962. C.727- a new blight-resistant gram variety for Barani areas. W. Pakist. J. Agr. Res. 1: 165-166.

BEDI, K.S. and ATHWAL, D.S. 1962. C-235 is the answer to blight. Indian Fmg. 12(9): 20-22.

BEDI, P.S. and AUJLA, S.S. 1969. Variability in *Phyllosticta rabiei* (Pass.) Trott., the incitant of blight disease of gram. J. Res. Punjab Agric. Univ. 6: 103-106.

BEDI, P.S. and AUJLA, S,S. 1970. Factors affecting the mycelial growth and the size of pycnidia produced by *Phyllosticta rabiei* (Pass.) Trot., the incitant of gram blight. J. Res. Punjab Agric. Univ. 4: 606-609.

BENLLOCH, M., 1941. Some phytopathological characteristics of the year 1941 (in Spanish). Bol. Pat. Veg. Ent. Agr., Madr. X, 29-32: 1-14.

BENLLOCH, M. and DEL CANIZO, J. 1931. The anthracnose of chickpeas (in Spanish). Bol. Pat. Veg. Ent. Agr. V, 19-22: 128-133.

BIGGS, C.E.G. 1944. Annual Report, Department of Agriculture, Tanganyika Territory, 1943. 8 pp.

BONDARTZEVA-MONTEVERDE, Mme V.N. and VASSILIEVSKY, N.I. 1940. A contribution to the biology and morphology of some species of *Ascochyta* on Leguminosae (in Russian). Acta Inst. Bot. Acad. Sci. USSR, 1938, Ser.II: 345-376.

BUTLER, E.J. 1918. Fungi and disease in plants. Bishen Singh Mahendra Pal Singh, New Connaught Place, Dehradun Periodical Experts, 42-D, Vivek Vihar, Delhi 32, 547 pp. (reprinted 1973).

CHAUHAN, R.K.S. and SINHA, S. 1973. Effect of varying temperature, humidity and light during incubation in relation to disease development in blight of gram (*Cicer arietinum*) caused by *Ascochyta rabiei*. Proc. Natn. Sci. Acad., India. B. 37: 473-482.

DEMETRIADES, S.D., ZACHOS, D.G., CONSTANTINOU, P.T., PANAGOPULOS, C.G. and HOLEVAS, C.D. 1959. Brief reports on the principal plant diseases observed in Greece during the year 1958 (in French). Ann. Inst. Phytopath. Benaki, N.S., 2, 1: 3-11.

ESER, D. 1976. Heritability of some important plant characters, their relationships with plant yield and inheritance of *Ascochyta* blight resistance in chickpea (*Cicer arietinum* L.) (in Turkish). Ankara Universitesi Ziraat Fakultesi Yayinlari 620, 40 pp.

FAO. 1978. Production Yearbook 32: 124.

GANEVA, D. and MATSOV, B. 1977. Comparative testing of introduced and local samples of chickpea. Rasteneiv dni Nanki 14(9): 51-59.

GOBELEZ, M. 1956. Research work on the varieties and areas of spread of bacterial and parasitic diseases affecting and contaminating the seeds of cultivated plants grown in certain provinces of Central Anatolia as well as the approximate degree of damage caused by such diseases (in Turkish). Zir. Fak. Yayinl., 107, 62, 131 pp.

GONZALEZ, F,R, 1921. New or little-known Sphaeropsidales of the Spanish fungus flora (in Spanish). Association Espanola para el Progreso de las Ciencias. Congreso de Oporto, VI. Ciencias Naturales: 35-57.

GORLENKO, M.V. and Mme BUSHKOVA, L.N. 1958. Perfect state of the causal agent of ascochytosis of chickpea (in Russian). Plant Prot., Moscow 3:60.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to *Ascochyta* blight. Indian Phytopath. 27: 643-645.

HAFIZ, A. 1952. Basis of resistance in gram to *Mycosphaerella* blight. Phytopathology 42: 422-424.

HAFIZ, A. and ASHRAF, M. 1953. Studies on the inheritance of resistance to *Mycosphaerella* blight in gram. Phytopathology 43: 580-581.

HALFON-MEIRI, A. 1970. Infection of chickpea seeds by *Ascochyta rabiei* in Israel. Plant Dis. Reptr. 54: 442-445.

HAWARE, M.P. and NENE, Y.L. 1981. Phoma blight – A new disease of chickpea. Plant Dis. 65: 282.

IBRAGIMOV, G.R., AKHMEDOV, S.A. and GARADAGI, S.M. 1966. Use of phenthiuram and phenthiuram molybdate against diseases of Fodder Beans and *Cicer arietinum* under Azerbaidzhani conditions. Khimiya sel'. Khoz. 4: 23-24.

KAISER, W.J. 1972. Occurrence of three fungal diseases of chickpea in Iran. FAO Plant Prot. Bull. 20: 74-78.

KAISER, W.J. 1973. Factors affecting growth, sporulation, pathogenicity, and survival of *Ascochyta rabiei*. Mycologia 65: 444-457.

KAISER, W.J., OKHOVAT, M. and MOSSAHEBI, G.H. 1973. Effect of seed treatment fungicides on control of *Ascochyta rabiei* in chickpea seed infected with the pathogen. Plant Dis. Reptr. 57: 742-746.

KAUSAR, A.G. 1965. Epiphytology of recent epiphytotics of gram blight in West Pakistan. Pakistan J. Agri. Sci. 2: 185-195.

KHACHATRYAN, M.S. 1961. Seed transmission of ascochytosis infection in chickpea and the effectiveness of treatment (in Russian). Sbor. nauch. Trud. nauch. issled. Inst. Zemledel. Armyan, S.S.R. 2: 147-155.

KHACHATRYAN, M.S. 1962. Some problems of the biology and dynamics of development of ascochytosis of chickpea in the Armenian S.S.R. (in Russian). Izv. Akad. Nauk. Armyan, S.S.R. biol. Sci. 15: 23-30.

KHUNE, N.N. and KAPOOR, J.N. 1980. *Ascochyta rabiei* synonymous with *Phoma rabiei*. Indian Phytopath. 33: 119-120.

KOVACHEVSKI, I.C. 1936a. The blight of chickpea, *Mycosphaerella rabiei* n. sp. (in Russian). Issued by Min. Agric. Nat. Domains, Sofia, 80 pp.

KOVACHEVSKI, I.C. 1936b. Parasitic fungi new for Bulgaria. Fourth contribution (in Russian). Trav. Soc. Bulg. Sci. Nat. 27: 13-24.

LABROUSSE, F. 1930. Anthracnose of the chickpea (*Cicer arietinum*)(in French). Rev. Path. Veg. et Ent. Agr. 27: 174-177.

LABROUSSE, F. 1931. Anthracnose of chickpea (in French). Rev. Path. Veg. et Ent. Agr. 28: 226-231.

LUKASHEVICH, A.I. 1958a. Control measures against ascochytosis of chickpea (in Russian). J. Agric. Sci., Moscow 5: 131-135 (Rev. Appl. Mycol. 37: 62, 1958).

LUKASHEVICH, A.I. 1958b. Peculiarities of the parasitism of the causal agent of ascochytosis of chickpea, and their role in the accumulation of infection (in Russian). Rep. Acad. Sci. Ukr. 7: 788-792 (Rev. Appl. Mycol. 39: 647, 1960).

LUTHRA, J.C. and BEDI, K.S. 1932. Some preliminary studies on gram blight with reference to its cause and mode of perennation. Indian J. Agr. Sci. 2: 499-515.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1935. Life history of gram blight (*Ascochyta rabiei*) (Pass.) Lab. = *Phyllosticta rabiei* (Pass.) Trot. on gram (*Cicer arietinum* L.) and its control. Punjab Agr. Live-Stk. India 5: 489-498.

LUTHRA, J.C. SATTAR, A. and BEDI, K.S. 1938. The control of the blight disease of gram by resistant types. Cur. Sci. 7 (2): 45-47.

LUTHRA, J.C., SATTAR, A. and BEDI K.S. 1939. Variation in *Ascochyta rabiei* (Pass.) Labr., the causal fungus of blight of gram (*Cicer arietinum* L.). Indian J. Agr. Sci. 9: 791-805.

MADEN, S., SINGH, D. MATHUR, S.B. and NEERGAARD, P. 1975. Detection and location of seed-borne inoculum of *Ascochyta rabiei* and its transmission in chickpea (*Cicer arietinum*). Seed Sci. & Tech. 3: 667-681.

MORRALL, R.A.A. and McKENZIE, D.L., 1974. A note on the inadvertent introduction to North America of *Ascochyta rabiei*, a destructive pathogen of chickpea. Plant Dis. Reptr. 58: 342-345.

NEMLIENKO, F.E. and LUKASHEVICH, A.I, 1957. Agrotechnical measures against ascochytosis of chickpea (in Russian). Plant Prot., Moscow 4: 31-33 (Rev. Appl. Mycol. 37: 627, 1958).

NENE, Y.L. 1980. A world list of pigeonpea (*Cajanus cajan* (L.) Millsp.) and chickpea (*Cicer arietinum* L.)pathogens. ICRISAT Pulse Pathology Progress Report 8, 14 pp.

PADWICK, G.W. 1948. Plant Protection and Food Crops of India. I. Plant pests and diseases of rice, wheat, sorghum and gram. Emp. J. Exp. Agr. 16: 55-64.

PUERTA ROMERO, J. 1964. Gram blight: isolation of the fungus *P. rabiei* and the study of gram varieties possibly resistant to it (in Spanish). Boln. Patol. Veg. Ent. Agr. 27: 15-52.

RADKOV, P. 1978. Biological and economic properties of some new varieties of chickpea. Rasteniev dni Nanki 15(1): 81-87.

RADULESCU, E., CAPETTI, E., SCHMIDT, E. and CASSIAN, A. 1971. Contributions to the study of anthracnosis of chickpea (*Mycosphaerella rabiei* Kov.) (in Romanian). Lucrari Stuntifice 14: 311-321.

REDDY, M.V., and NENE, Y.L. 1979. A case for induced mutation in chickpea for *Ascochyta* blight resistance. Pages 398-408 in Proc. Symp. on the Role of Induced Mutations in Crop Improvement. Osmania Univ.,Hyderabad, India.

REDDY, M.V. 1980. An effective fungicide for eradication of *Ascochyta rabiei* in chickpea seed. International Chickpea Newsletter 3:12.

REDDY, M.V. and SINGH, K.B. 1980. Effect of inter-row spacing on the reaction of chickpea lines to *Ascochyta* blight. International Chickpea Newsletter 3:13.

REDDY, M.V., NENE, Y.L. and SINGH, K.B. 1980. Field screening of chickpeas for resistance to *Ascochyta* blight. International Chickpea Newsletter 2: 13-15.

RETIG, B. and TOBOLSKY, J., 1967. A trial for the control of *Ascochyta* in chickpeas. First Israel Congr. Pl. Path: 50-51.

SATTAR, A. 1933. On the occurrence, perpetuation and control of gram (*Cicer arietinum* L.) blight caused by *Ascochyta rabiei* (Pass.) Labrousse, with special reference to Indian conditions. Ann. Appl. Biol. 20: 612-632.

SATTAR, A. 1934. A comparative study of the fungi associated with blight diseases of certain cultivated leguminous plants. Trans. Brit. Mycol. Soc. 18: 276-301.

SATTAR, A. and HAFIZ, A. 1951. A practical method of inoculating gram *Ascochyta rabiei* on a field scale. Pages 1-2 *in* Proc. Third Pakistan Sci. Conf.

SE, NYCIREK, M., OLC, UN, and ZAVRAK, Y. 1977. Preliminary studies on the chemical control of chickpea anthracnose (*Mycosphaerella rabiei* Kovacevski) in the Black Sea region. Zirai Mucadale Aras, tirma yilbigi, No. 11, 71-72.

SINGH, G. 1978. Screening of genetic stock of gram against blight. Indian J. Mycol. & Plant Path. 8: 124.

SINGH, K.B., HAWTIN, G.C., NENE, Y.L. and REDDY, M.V. 1981. Resistance in chickpeas to *ascochyta blight*. Plant Dis. 65:586-587.

SOLEL, Z. and KOSTRINSKI, J. 1964. The control of *Ascochyta* anthracnose of chickpea. Phytopath. Mediterranea 3: 119-120.

SPRAGUE, R. 1930. Notes on *Phyllosticta rabiei* on chickpea. Phytopathology 20: 591-593.

VEDYSHEVA, R.G. 1966. Evaluation of the resistance of Cicer arietinum to *Ascochyta rabiei* (in Russian). Vest. sel'. khoz. Nauki, Mosk. 11(12): 109-111.

VIR, S. and GREWAL, J.S. 1974a. Peroxidase activity associated with *Ascochyta* blight of gram (*Cicer arietinum* L.). Phytopathologia Mediterranea 13: 174-175.

VIR, S. and GREWAL, J.S. 1974b. Physiologic specialization in *Ascochyta rabiei*, the causal organism of gram blight. Indian Phytopath. 27: 255-360.

VIR, S. and GREWAL, J.S. 1974c. Changes in phenolic content of gram plant induced by *Ascochyta rabiei* infection. Indian Phytopath. 27: 524-526.

VIR, S. and GREWAL, J.S. 1974d. Evaluation of fungicides for the control of gram blight. Indian Phytopath. 27: 641-643.

VIR, S. and GREWAL, J.S. 1975a. Role of free amino acids in disease resistance to gram blight. Indian Phytopath. 28: 206-208.

VIR, S. and GREWAL, J.S. 1975b. Change in catalase activity of gram plant induced by *Ascochyta rabiei* infection. Indian Phytopath. 28: 223-225.

VIR, S. GREWAL, J.S. and GUPTA, V.P. 1975. Inheritance of resistance to *Ascochyta* blight in chickpea. Euphytica 24: 209-211.

ZACHOS,D G. 1951. Studies on the disinfection of chickpea seeds *(Cicer arietinum* L.) infected with *Ascochyta rabiei* (Pass.) Labr. (in French). Ann. Inst. Phytopath. Benaki, 5, 2: 76-87.

ZACHOS, D. G. 1952. A case of parasitism of chickpea (*Cicer arietinum* L.) seeds by *Stemphyllium botryosum* Wallr. (in French). Ann. Inst, Phytopath. Benaki, 6, 2: 60-61.

ZACHOS, D.G., PANAGOPULOS, C.G. and MAKRIS, S.A. 1963. Researches on the biology, epidemiology and the control of anthracnose of chickpea (in French). Annls. Inst. Phytopath. Benaki, N.S., 5(2): 167-192.

ZALPOOR, N. 1963. *Mycosphaerella rabiei* Kovacevski (*Ascochyta rabiei*) (Pass.) Lab. (in Farsi). Ent. Phytop. Appl., Tehran 21: 10-12.

Discussion

M. Aslam

What is your idea about the frequency of occurrence of ascochyta blight in Punjab (India), that is, whether the disease is increasing there or decreasing?

Y.L. Nene

The disease was not actually increasing, but there are areas in Punjab (India) like Gurdaspur where the disease can occur and has been seen to occur.

T.S. Sandhu

There was a severe epidemic of blight during 1967-68, but after that it has not been observed.

K.B. Singh

In Punjab State of India blight epidemic in chickpea occurred in a form during the 1967-68 season that the farmers did not even harvest the crop. But the next year and subsequent years this disease was not even seen. So I feel that epidemiology is not fully understood and more needs to be known.

Y.L. Nene

I would like to say that there is no increase in the frequency of ascochyta blight epidemic in India. The disease is endemic in Gurdaspur, and depending upon weather conditions, it reaches epidemic proportions in certain years.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Epidemiological Aspects of Chickpea Ascochyta Blight

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A devastating plant disease such as the one caused by *Ascochyta rabiei* on chickpeas has to be thoroughly understood if control is to be achieved with a reasonable degree of certainty. Within the framework of the ICARDA/ICRISAT effort to study and control ascochyta blight, we have tried to understand some of the epidemiological aspects of this disease.

Taking into account the massive epiphytotics as the ones reported from Pakistan in the last two seasons or those noted on susceptible winter-planted chickpeas in Syria, the question arises as to how such massive outbreaks are biologically achieved and how they can be manipulated by changing the genetic resistance and the planting date. In this paper we discuss some findings on four different aspects of the disease cycle:

(1) the epiphytotic spread of the disease on growing plants,
(2) the climatic conditions for infection,
(3) the role of contaminated plant debris for disease initiation, and
(4) the role of infected seeds for disease initiation.

Methods and Material

A disease assessment key was developed, based on nine grades between 1 and 100% leaf and stem area infected. Conditions for infection were studied in growth chambers and the saturated atmosphere required was maintained under plastic bags. Plants were dried with a fan after the required times and placed in a plastic greenhouse for 14 days to allow disease development. All field trials mentioned here were conducted at the Tel Hadya Research Station near Aleppo, Syria. All seeds were supplied by the Food Legume Improvement Program of ICARDA.

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Results

Epiphytotic Spread of the Disease

In both years three different cultivars were used but this report includes only results of the susceptible local landrace ILC 1929 and the resistant selection ILC 482. They were studied at four different planting dates, but in the 1979-80 season the seedlings from the two later planting dates were destroyed by birds. Figure 1 shows the epiphytotic curves for disease incidence percentage and disease intensity for 1979-80. It is worth noting that at the date of the first reading in early March the disease incidence of the early planted susceptible crop was already 30%, which indicates that disease development must have started by mid-February. Both cultivars developed a very high percentage of diseased plants but differed significantly in their disease intensity ratings. Though nothing is known on the type of resistance in ILC 482, it may be partly associated with the fungus growth rate and sporulation after infection.

The data obtained up to April 28 in the 1980-81 growing season are presented in Figure 2. They confirm all findings from the previous season and also indicate the effect of late planting on the epiphytotics. Only the latest planting date brought the disease intensity of the susceptible cultivar down to acceptable levels. Again, the disease did not occur before mid-February, even with the earliest planting date. A striking feature in both years was the extremely fast disease development that began during mid-March.

Infection Conditions

The results presented above raise the question about the environmental factors that control infection. As spores are only released from pycnidia if they are wet, wetness of the plant surface must be a pre-condition for surface contamination and effective short or long distance spread by wind. A study of the wetness duration and temperature requirements for successful infection was therefore carried out to determine the climatic conditions necessary for disease development. It was found that the disease intensity increased with increased wetness duration over a wide range of temperatures (Fig. 3). However, a steep increase at shorter wetness durations of up to 10 hours was only apparent between 9 and 21°C. The irregularities occurring at 15°C were not significant and probably stemmed from insufficient environmental control in the growth chambers used.

If one excludes all infection data below 1% as insignificant, the limiting conditions for infection can be defined. Figure 4 shows that no infection occurred below 6°C irrespective of the wetness duration and under wetness periods shorter than 6 hours irrespective of the prevailing temperature. The maximum temperature allowing infection must be close to 30°C.

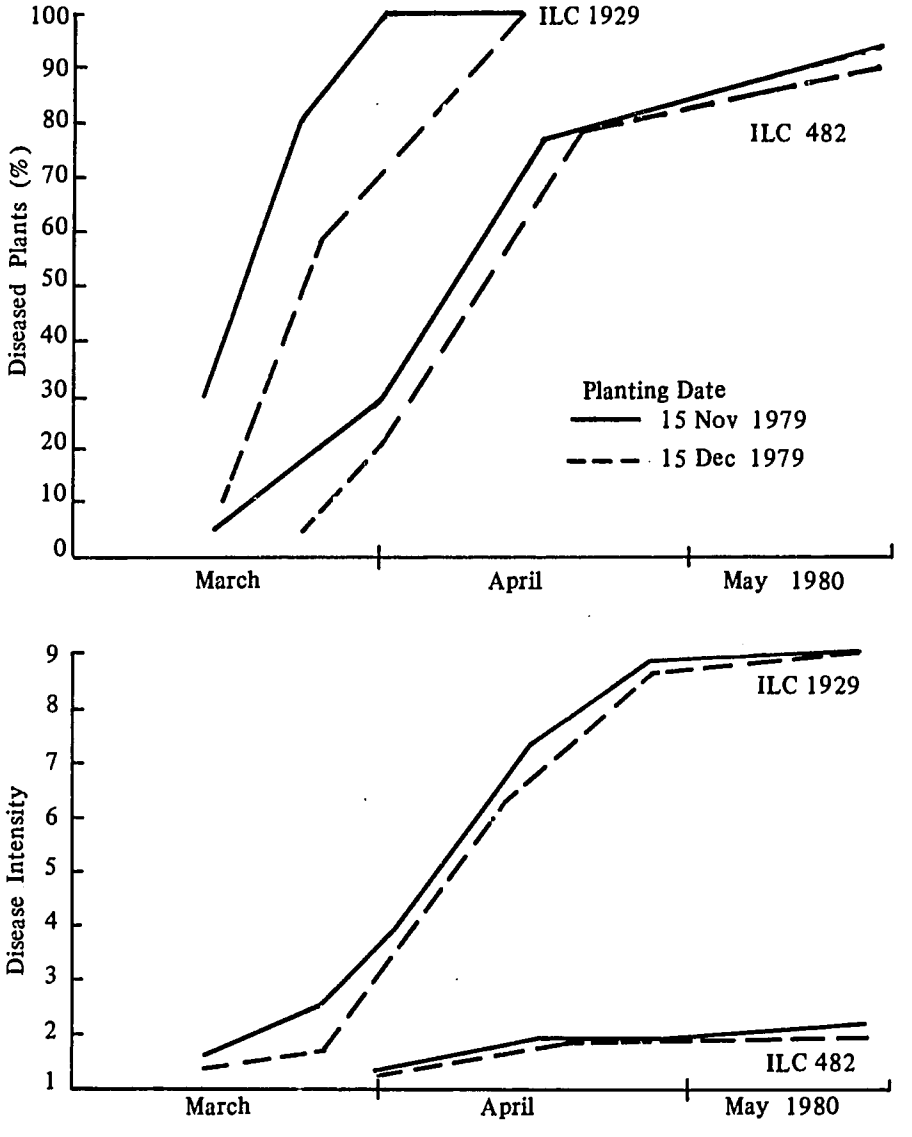


Figure 1. *Ascochyta* disease developments on two chickpea lines – local landrace ILC 1929 (susceptible) and selection ILC 482 (resistant) in the 1979-80 growing season.

If these data are compared with the climatic data from the Aleppo region it is apparent that daily average air temperatures do not increase above 6°C before mid-February and above 10°C before mid-March. A more detailed analysis of

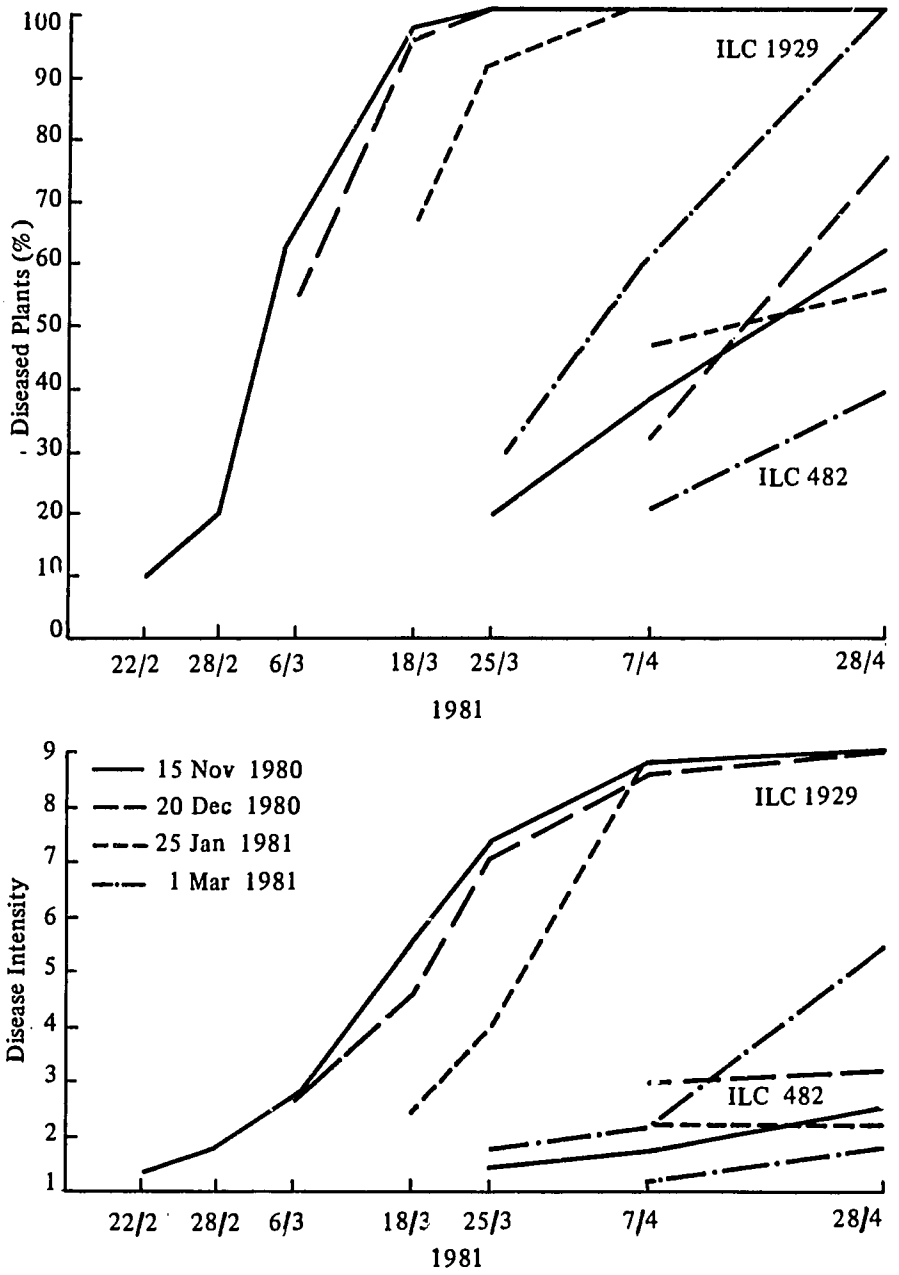


Figure 2. *Ascochyta* disease developments on two chickpea lines – local landrace ILC 1929 (susceptible) and selection ILC 482 (resistant) in the 1980-81 growing season.

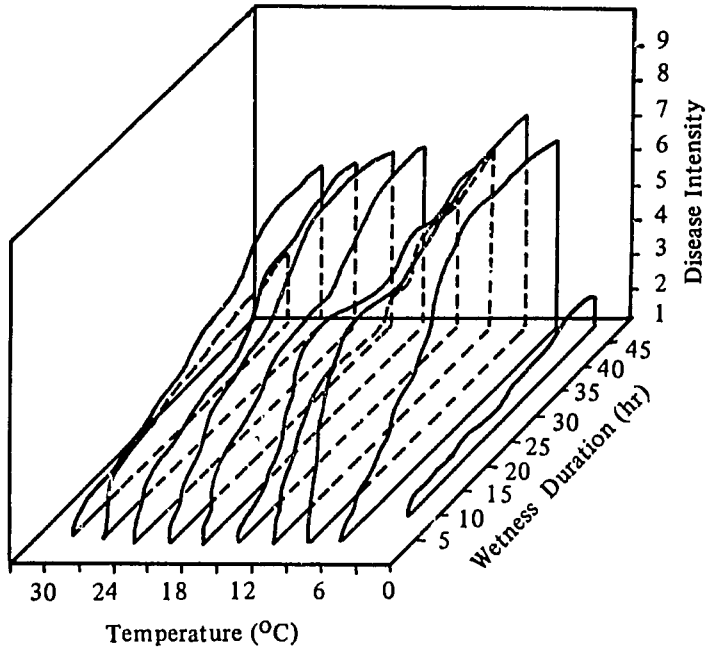


Figure 3. *Ascochyta* disease intensity in relation to temperature and wetness duration during the infection period.

temperature data during rain periods or recorded wetness periods, when completed, might provide further evidence that a slow infection was possible in February but the epiphytotic did not spread before mid-March. Based on these findings it seems possible to identify locations of specific high or low disease incidence probability.

Role of Infected Plant Debris in Disease Initiation

In the 1980-81 season, soil was infested in five microplots within an isolated field plot and disease incidence and spread was then monitored on a single-plant basis. Figure 5 shows the trend of disease development between February 25 and March 25. Obviously, primary infection occurred only in one microplot and only 11 plants were diseased by February 25. Though all seeds were hand selected for freedom of Ascochyta symptoms, it cannot be excluded that some seeds passed through as symptomless carriers. Thus, one may conclude that the role of plant debris for disease initiation is very limited, as massive soil infestation can only occur on highly infected fields, where chickpeas are not likely to follow again in

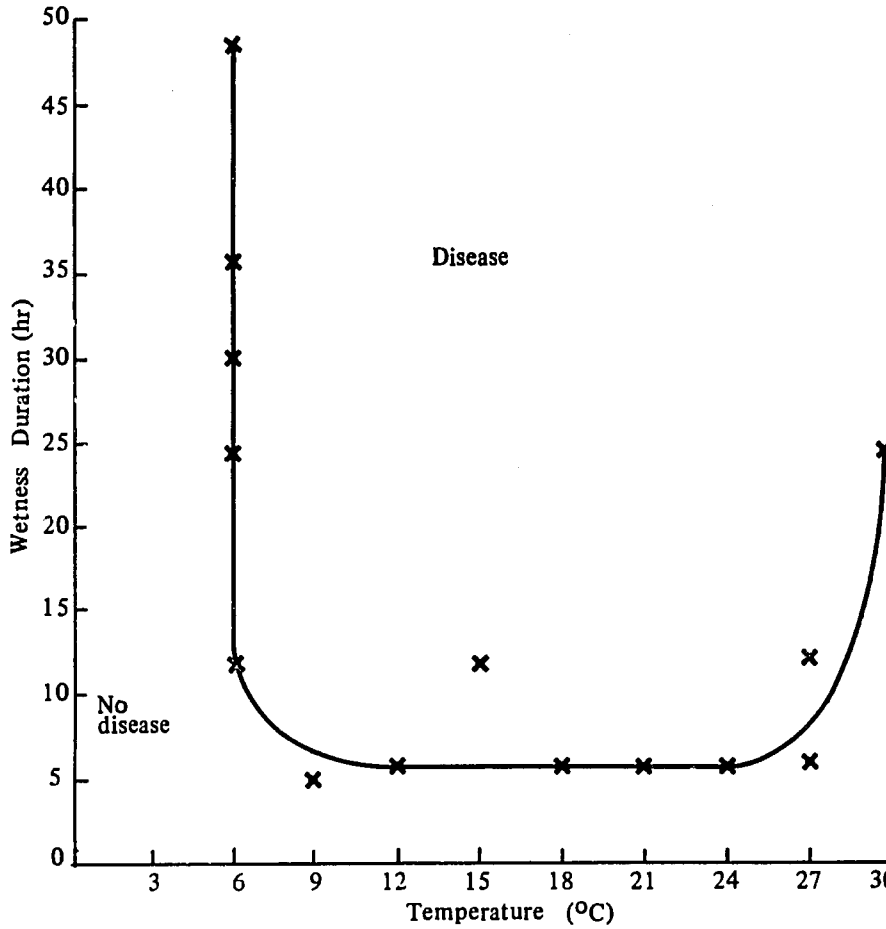
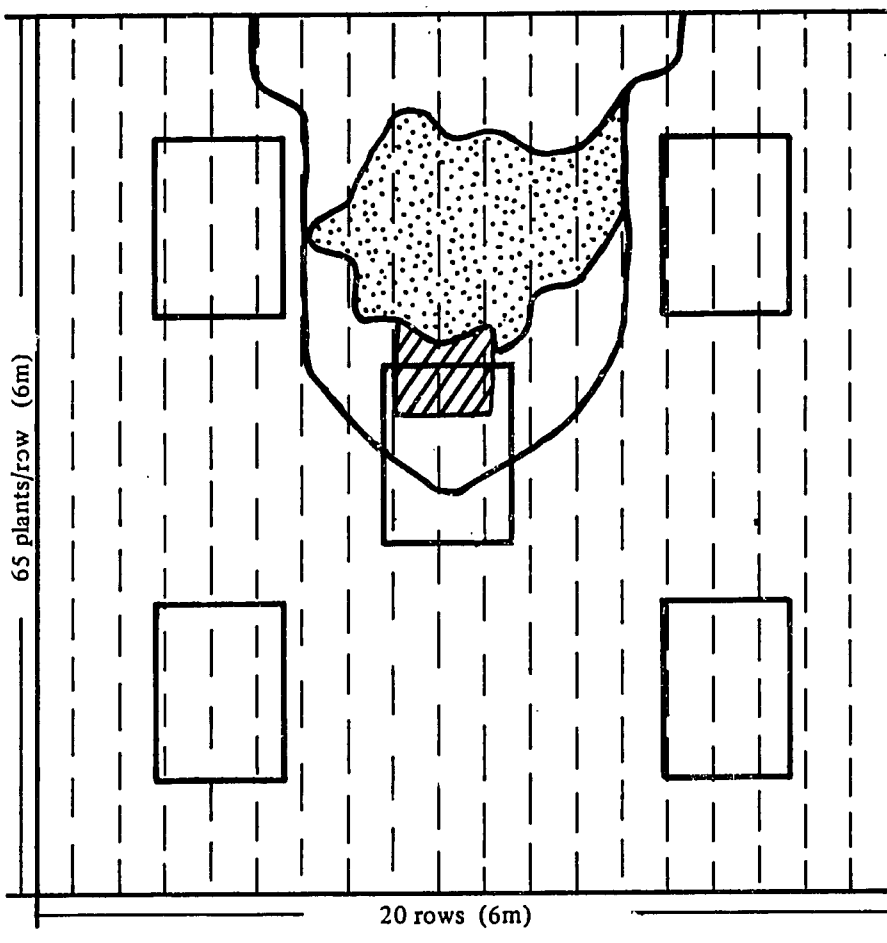


Figure 4. Minimum periods of wetness duration and minimum temperatures for *Ascochyta* infection on chickpea.

the rotation. The amount of debris mixed with seed is, on the other hand, not very large, which again cuts down the probability for successful transmissions.

Role of Infected Seeds in Disease Initiation

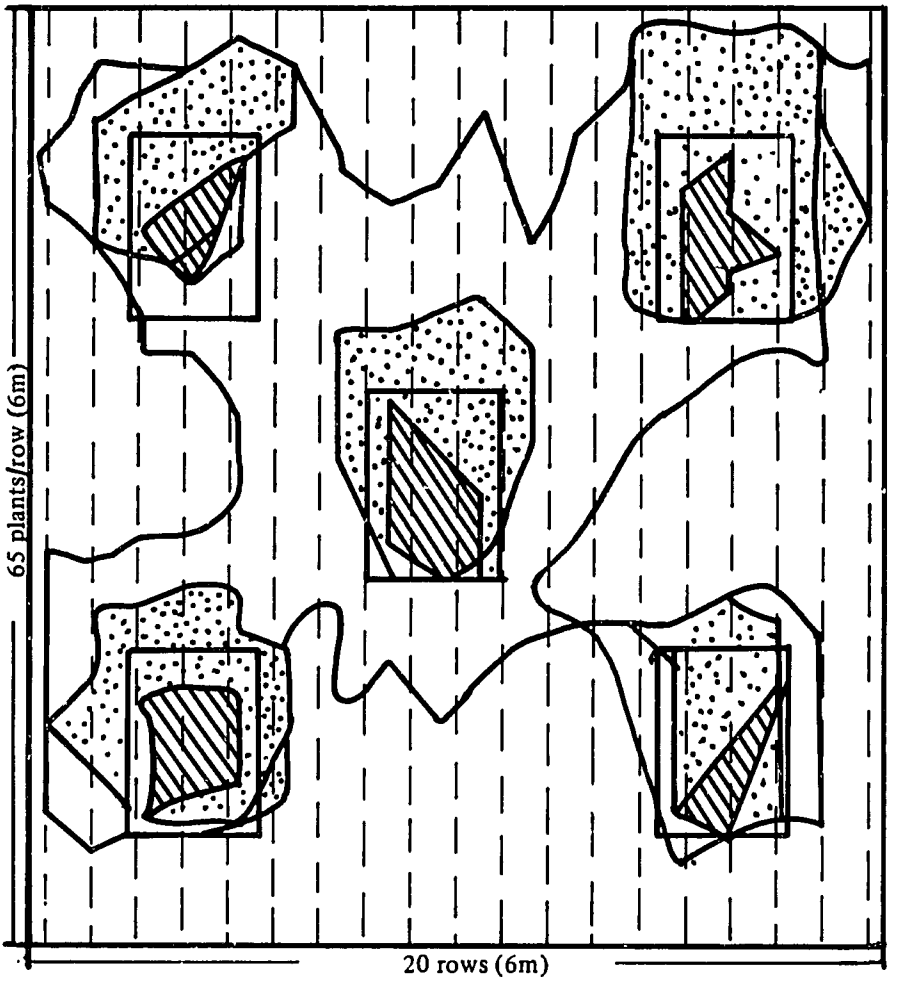
Five microplots with 19 infected seeds each were prepared inside a macroplot of susceptible chickpeas. The disease started on February 2, i.e., 3 weeks before the first appearance in the debris-infested plots (Fig. 6). In all five microplots the disease spread very rapidly. By March 26, 100% infection was reached. The



	Diseased plants	Infection %
Nov 26 5 infected areas of 8280 cm^2 each	0	0
Feb 25	11	0.8
Mar. 11	80	6.2
Mar 25	204	15.7

Figure 5. *Ascochyta* spread from infected debris, 1980-81.

development of this micro-epiphytotic is in full agreement with the data taken from the non-isolated macroplots as presented in Figure 2. It seems clear that



	Diseased plants	Infection %
Nov 26 19 diseased seeds/square	0	0
Feb 2	32	2.4
Feb 16	160	12.4
Feb 24	327	25.2
Mar 12	1100	85.4
Mar 26	1300	100.0

Figure 6. *Ascochyta* spread from infected seeds, 1980-81.

infected seed is a much more potential source of inoculum than plant debris considering the fact that out of 95 infected seeds 32% produced primary infected plants.

Conclusions

Although the final analysis of our data has not yet been completed, the following conclusions may be drawn and used as a base for further work:

1. Planting date delays the epiphytotic only if it is delayed beyond the beginning of the natural epiphytotic.
2. The epiphytotic curve is characteristic for the degree of resistance of a cultivar.
3. Disease intensity is a more reliable parameter for resistance than disease frequency.
4. The onset of an epiphytotic is defined by weather data.
5. Disease of any significance cannot develop below average air temperatures of 6°C and with wetness periods less than 6 hours.
6. Fast epiphytotic development occurs between 9 and 24°C and at wetness periods of 10 hours and more.
7. Plant debris is a very inefficient soil-borne source of inoculum.
8. Infected seeds are very efficient sources of inoculum.
9. Disease control in winter chickpeas should be based on healthy seeds, seed treatment, genetic resistance and selection of proper locations.

Discussion

R. Pieters

If you use a percentage scale, how do you score a branch which died because of one lesion at the base of the branch?

H.C. Weltzien

We have no special score for this situation but early stages of infection are covered by our scale and at late stages we can score the actual percentage of dead plant surfaces.

J.S. Grewal

Our experience shows that stem infection is more important than leaf infection from the point of view of damage.

H. Haddad

Is there any simple method to identify infected seeds in a seed lot? Further if you have a lesion, will this be enough to contaminate the seed lot?

H.C. Weltzien

There could be visible and invisible infection. The first is easy to identify. The second can only be detected by seed health tests.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Screening Techniques for Ascochyta Blight of Chickpea

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A joint contribution from ICRISAT and ICARDA centers

Blight caused by *Ascochyta rabiei* (Pass.) Lab. is the major disease of chickpea in North Africa, West Asia and South and East Europe. The use of resistant cultivars is considered to be the best way of controlling the disease. Though considerable work has been done on the development of screening techniques, rating scales and other related aspects, simple and reliable techniques for large-scale field screening were not available. The earlier methods of inoculation for field screening consisted of spraying with a pycnidiospore suspension from the pure culture of the fungus and covering the plants with "Sarkanda" screens or cloth tents, or spreading the diseased chickpea debris, or dried culture of the fungus over the plants, or mixing the diseased plant debris with seed at the time of sowing and depending on natural rainfall for disease development (Luthra *et al.* 1938; Grewal and Vir 1974; Bedi 1949).

These methods were not adequate for large-scale field screening of germplasm lines and breeding materials. Similarly, greenhouse or pot culture screening techniques for large-scale screening were not available. Lack of reliable field-screening techniques for large-scale screening of germplasm lines and breeding materials, hampered the progress on resistance breeding. A need for further standardization of both field and laboratory screening techniques as well as rating scales was felt. The results of the field and greenhouse screening techniques and the rating scales standardized for evaluating the materials are presented in this paper.

Field-Screening Techniques

During the 1977-78 season, when research on ascochyta blight of chickpea started at ICARDA, a great need was felt for a simple, efficient and reliable

field-screening technique. Based on the experience gained during the 1977-78 season, when a spray with pycnidiospore suspension prepared from the naturally infected plants under natural rainfall conditions did not provide sufficient disease pressure (none of the susceptible checks were killed), debris method of inoculation (Luthra *et al.* 1938; Sattar and Hafiz 1951) coupled with supplementary sprinkler irrigation was considered. The method was tested during the 1978-79 season and the results were excellent. Singh *et al.* (1981) described the technique which involved a combination of inter-planting a susceptible spreader line, scattering between rows infected debris collected from the previous season, spraying pycnidiospores harvested from the infected plants of a susceptible line, and providing sprinkler irrigation. This technique has been further standardized (Reddy *et al.* 1980) and the results of the experiments and observations made are presented here.

Type of Debris

During the 1978-79 season, diseased debris was cut into small bits and was used for inoculation, whereas during the 1979-80 and 1980-81 seasons diseased stalks as such were used. Based on the disease severity obtained during these 3 years, it appears that the latter is superior to the former.

Spreader Rows vs. Whole Plot Inoculation

The disease severity was compared between plots with only the spreader rows (every third or fifth) inoculated and the entirely inoculated plots. The disease spread and severity was found to be greater in entirely inoculated plots than plots where only the spreader rows were inoculated. The disease spread was slightly faster in plots where a spreader row was sown after every two test rows than in those where spreader rows were sown after every four test rows.

Frequency of Indicator-cum-Spreader Rows

The disease severity in plots where the indicator-cum-spreader rows sown after every 2, 4 and 8 test rows were inoculated and in those where the entire plots were inoculated was found to be the same under sprinkler irrigation. This suggests that spreader rows in the debris method of inoculation do not play a significant role in disease spread and serve mainly as indicator rows.

Row Direction

Planting of rows in East-West or North-South direction was found to have no effect on disease severity in plots that were inoculated entirely. In plots where only the spreader rows were inoculated, the disease spread was slightly faster in plots where the rows were planted in a North-South direction as the wind direction was East-West.

Date of inoculation: Inoculations with diseased debris from December through

early February were found to give equally severe infections with sprinkler irrigation under ICARDA farm conditions. Inoculation after February without sprinkler irrigation was found unreliable.

Methods of inoculation: The efficiency of different methods of inoculation with and without sprinkler irrigation was compared. The inoculation methods compared were (i) diseased debris, (ii) pycnidiospore suspension from pure culture of the fungus, and (iii) freshly infected plants. Under sprinkler irrigation all the three methods gave equally severe infection. Without sprinkler irrigation, the debris method was found to be superior. The optimum time for immersing infected plants in water for the maximum release of spores was found to be one hour.

Flat vs. Ridge Planting

Observations on flat and ridge plantings indicated a comparatively fast and severe disease development in flat plantings.

Effect of Irrigation Water

To determine whether the water used for sprinkler irrigation has any effect on disease development, the germination of spores in irrigation water and sterile distilled water was compared, but no appreciable difference was found.

Viability of Pycnidiospores in Diseased Debris

The viability of pycnidiospores was studied in (i) 1-year-old diseased debris stored dry, (ii) diseased debris left over in the field from previous season, (iii) freshly infected plants, and (iv) pure culture of 10-day-old fungus. The percent germination of spores after 12 hr incubation in the above treatments was 9, 55, 56 and 59, respectively. But the germination of spores from infected debris increased with time indicating that they needed more time for germination.

Effect of Plant Spacing

To determine if the plant spacing has any effect on resistance, reaction of a set of lines that included six resistant, four tolerant, nine susceptible, and six highly susceptible lines was studied at two inter-row spacings of 20 and 30 cm. No difference was found (Reddy and Singh 1980).

The method of inoculation with a pycnidiospore suspension of the fungus followed by covering the inoculated plants with screens or cloth tents used by Luthra *et al.* (1938) and Grewal and Vir (1974) is not practicable for large-scale adoption. The debris method of inoculation (Luthra *et al.* 1938, 1941; Sattar and Hafiz 1951; Vedysheva 1966) and the use of dried cultures of the fungus (Bedi 1949) under Syrian conditions where the rainfall is low, were found inadequate for creating high disease pressure.

Uniform inoculation in the first fortnight of February with coarse diseased

debris of chickpea collected from the previous season coupled with sprinkler irrigation when necessary was found to be simple, efficient and reliable for a large-scale field screening.

Bedi (1949) claimed that the method of using dried cultures of the fungus was superior to the debris method because in the debris method, inoculations had to be delayed until sufficient fresh blighted material became available and the diseased material from the previous season could not be relied upon due to the low viability of the fungus. The present study indicated that the debris collected in the previous season can safely be used. Luthra *et al.* (1938) and Kaiser (1973) claimed that the fungus in diseased debris remained viable for more than [illegible] years.

Further, the debris method can be more useful in places where no laboratory facilities or pathologists are available. The only lacuna in this method is that there is no exact monitoring of either the quantity or quality of the inoculum being used every year. But this may be a blessing in disguise as it is more close to what happens in nature. The fact that none of the lines changed their reactions significantly during the 3 years of screening indicates that this does not pose a problem as far as the reliability of the results is concerned. In field inoculations, the pycnidiospore suspension spray either from a pure culture of the fungus or freshly infected plants can play a supplementary role when the disease severity is low due to insufficient diseased debris or any other reason.

Greenhouse or Pot Culture Screening Technique

The greenhouse or pot culture techniques used earlier for chickpea blight consisted of inoculating 10- to 40-day old plants grown in pots by spraying with a pycnidiospore suspension prepared from the pure culture of the fungus and by incubating them in humidity chambers for 2 to 6 days (Kaiser 1973; Chauhan and Sinha 1973; Vir and Grewal 1974). At ICRISAT Center, near Hyderabad, India where asochyta blight does not occur naturally, a need was felt for a greenhouse-screening technique to screen large numbers of germplasm. Initially, the usual methods of inoculating the potted plants and incubating them in humidity chambers were tried but were found unsatisfactory.

Isolation Plant Propagator Method

An isolation plant propagator manufactured by Burkard Manufacturing Co. Ltd., Rickmansorth, Herts, U.K., originally designed for the growing of healthy barley seedlings for epidemiological studies on powdery mildew was found to be very ideal for screening chickpea for ascochyta blight at ICRISAT Center. The unit mainly consists of a motor, four chambers in two tiers with filtered air being supplied to each of them through thick plastic pipes. Each chamber consists of a metallic tray covered with a wooden plank with holes for placing the pots. The

pot assembly consists of a stem that rests in the tray and passes through the bottom of the pot and with a plastic cover with two small holes in the top. The water is fed to the pot with cotton wicks. Each tray accommodates 30 pots and thus each unit 120 pots. When the motor is on, filtered air is sucked in and distributed to the trays filled with water to a certain level, becomes cooled, passes through the stems and builds up a pressure under the cover so that no external spores can enter the pots. High humidity maintained under the covers was found to help the blight development.

To facilitate better growth of chickpea seedlings, they were placed in a glasshouse where the temperature was maintained around 25°C through the help of fans and desert coolers. The unit was slightly modified by providing additional light to the lower chambers with four, 4-ft long 60 watt fluorescent tubes at the bottom of each of the two top trays. Using two such units, about 8000 lines were screened during a 3-year period.

For screening the germplasm, 10- to 15-day old seedlings of each accession (10 seedlings) in a single pot were inoculated by spraying with a spore suspension from a pure culture of the fungus. For inoculations, 10- to 15-day old culture multiplied on chickpea seed meal dextrose broth (80 g chickpea seed meal, 20 g dextrose, 1 liter water) and incubated at 20-25°C with 12 hr intermittent light was used. The concentration of spores in the suspension was 20,000 to 40,000/cc. Approximately 1.5 cc of spore suspension was sprayed on each seedling. Immediately after inoculation, the seedlings were covered with plastic covers. Symptoms usually developed in 4-6 days and the susceptible lines were completely killed in 10-15 days after inoculation. The technique can be very useful in studies on races.

Plastic House Screening

A plastic house provided with a perfo-irrigation system and temperature maintained at 20-25°C was found to be extremely suitable for pot culture screening at ICARDA Center. 10- to 15-day old plants grown in pots were inoculated by spraying with a pycnidiospore suspension of the pure culture of the fungus.

After inoculation, the perfo-irrigation was run for half an hour twice a day for 5 days. The symptoms appeared 7-10 days after inoculation and the susceptible lines were killed within 1 month after inoculation. Good correlation was found between disease ratings in field and plastic house screenings.

Disease Rating Scales

Six rating scales have been devised and used by various workers for scoring the blight severity (Aujla 1964; Aujla and Bedi 1967; Morrall and McKenzie 1974; Grewal and Vir 1974). To facilitate rapid evaluation of lines under pot culture conditions, Reddy and Nene (1978, 1979) evolved a 9-point scale. The scale has been described in the paper by Nene in these proceedings.

Singh *et al.* (1981) devised a modified 9 point scale for scoring the materials under field conditions where:

1 = No lesions visible on any plant (highly resistant)
3 = Lesions visible on less than 10% plants, no stem girdling (resistant)
5 = Lesions visible on up to 25% plants, stem girdling on less than 10% plants, but little damage (tolerant)
7 = Lesions present on most plants, stem girdling on less than 50% plants, resulting in the death of a few plants and causing considerable damage (susceptible)
9 = Lesions profuse on all plants, stem girdling present on more than 50% plants, and death of most plants (highly susceptible).

Though the 9-point rating scales were found to be very simple and practicable for a large-scale field evaluation of materials grown in a row or plot, some difficulty was experienced in rating the individual plants in segregating populations as the exact quantification of damage done to various parts of the plant was not specified under each reaction category. Even though chickpea is a highly self-pollinated crop, considerable variation in the reaction of individual plants of a line was observed. Leaf and stem lesion types and their combination considered by earlier workers (Aujla 1964; Grewal and Vir 1974) for categorizing the lines was found to be inadequate as considerable variation within and among the plants of a line was observed for such reaction. Further, the infection on pods was not considered in any of the previous scales. In order to arrive at a more accurate quantitative rating scale specifying the amount of damage done to various parts of the plant under each reaction category, the damage caused to various parts of the plant in lines representative of each reaction category was measured. The results are presented in Table 1. Based on these results a diagrammatic representation of 1-9 scale is proposed (Fig. 1).

Summary

Blight caused by *Ascochyta rabiei* (Pass.) Lab. is a major disease of chickpea in North Africa, West Asia, Pakistan and southern and eastern Europe. Importance of resistant cultivars in control of blight has been emphasized ever since early reports of the disease were made. Since simple and reliable screening techniques are essential for a successful resistance breeding program, a need was felt for further standardization of field and greenhouse screening techniques and rating scales.

A simple, efficient and reliable field-screening technique has been standardized at ICARDA and is being used for large-scale field screening of germplasm lines and breeding materials. The technique consists of sowing a susceptible cultivar in the field at frequent intervals to serve as indicator-cum-spreader line,

Table 1
A quantitative 9-point rating scale for Ascochyta blight of chickpea.

Disease Rating	Reaction category	Percent buds killed	Percent foliage infected	Percent stems with lesions	Percent stems broken	Stem lesion type	Leaf lesion type	Percent pods with lesions
1	Highly Resistant (HR)	Nil	Nil	Nil	Nil			Nil
2	Highly Resistant-Resistant (HR-R)	Nil	1.0	Nil	Nil		Necrotic with no or very few pycnidia	Nil
3	Resistant (R)	0–2.5	5.0	80.0	5.0	No lesions girdling	Necrotic with few pycnidia	5.0
4	Resistant-Tolerant (R-T)	0–5.0	20.0	80.0	15.0	2 mm long girdling	Necrotic with few pycnidia	15.0
5	Tolerant (T)	10.0	40.0	100.0	40.0	2 mm long girdling	Necrotic with large number of pycnidia	40.0
6	Tolerant-Susceptible (T-S)	25.0	50.0	100.0	50.0	2 mm long girdling	Necrotic with large number of pycnidia	50.0
7	Susceptible (S)	40.0	75.0	100.0	75.0	75% girdling	Necrotic with large number of pycnidia	75.0
8	Susceptible-Highly Susceptible (S-HS)	100.0	90.0	100.0	100.0	100% girdling	Necrotic with large number of pycnidia	100.0
9	Highly Susceptible (HS)	Plants completely killed						100.0

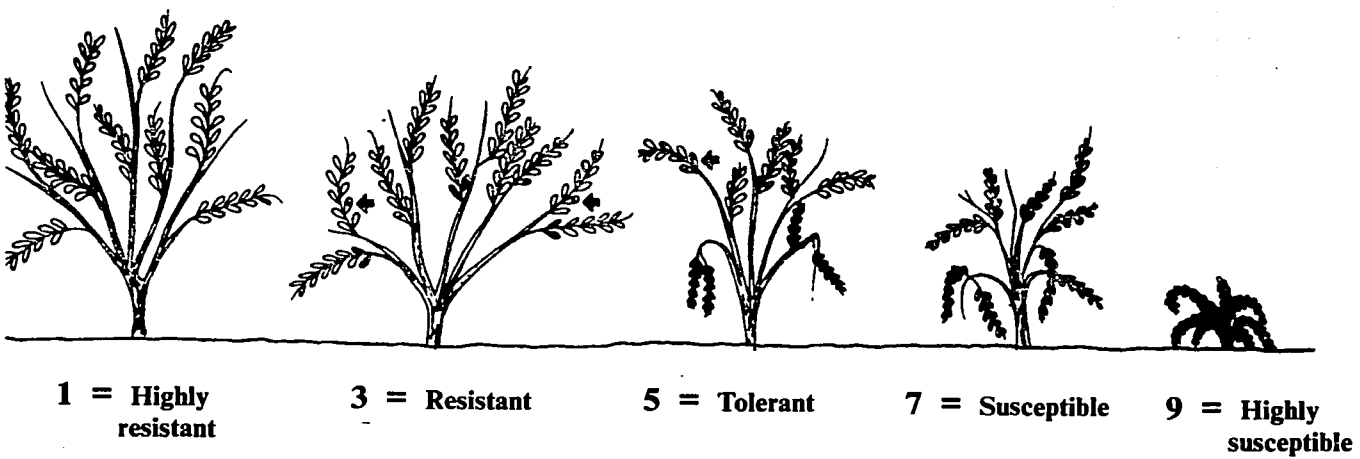

Figure 1. Diagrammatic representation of a 9-point rating scale for Ascochyta blight of chickpeas in the field.

inoculating the plants by uniformly scattering the diseased plant debris collected from the previous season throughout the field and providing sprinkler irrigation as and when necessary.

Satisfactory greenhouse and pot culture techniques were also standardized for the screening of germplasm. An isolation-plant propagator was found suitable for screening the germplasm round the year at ICRISAT center, where blight does not occur naturally. A plastic house provided with perfo-irrigation facility and temperature control was found to be very effective for pot culture studies at ICARDA. These techniques could also be useful at other locations.

A good correlation was found between the results of field screening by debris method of inoculation and the plastic house screening using the fungus pycnidiospore suspension.

A 9-point disease rating scale was devised and is being used for field and pot culture observations. A more comprehensive quantitative scale for scoring the segregating populations is proposed.

References

AUJLA, S.S. 1964. Study on eleven isolates of *Phyllosticta rabiei* (Pass.) Trot; the causal agent of gram blight in the Punjab, Indian Phytopathol. 17:83-87.

AUJLA, S.S. and BEDI, P.S. 1967. Relative reaction of different varieties of gram to blight disease incited by *Phyllosticta rabiei* (Pass.) Trot. in the Punjab. J. Res. Punjab agric. Univ. 4:214-216.

BEDI, K.S. 1949. Infestivity and longevity of dried cultures of *Ascochyta rabiei* (Pass.) Lab.; the causal fungus of gram blight. Indian Phytopathol. 2:6-10.

CHAUHAN, R.K.S. and SINHA, S. 1973. Effect of varying temperature, humidity and light during incubation in relation to disease development in blight of gram (*Cicer arietinum*) caused by *Ascochyta rabiei*, Proc. Natn. Sci. Acad., India, B.37:473-482.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to Ascochyta blight. Indian Phytopathol. 27:643-645.

KAISER, W.J. 1973. Factors affecting growth, sporulation, pathogenicity, and survival of *Ascochyta rabiei*. Mycologia 65:444-457.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1938. The control of the blight disease of gram. Curr. Sci. 2:45-47.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1941. Determination of resistance to the blight diesase (*Mycosphaerella rabiei*, Kovacevski – *Ascochyta rabiei* (Pass.) Lab. in gram types. Indian J. agric. Sci. 11:249-264.

MORRALL, R.A.A. and McKENZIE, D.L. 1974. A note on the inadvertant introduction to North America of *Ascochyta rabiei*, a destructive pathogen of chickpea. Plant Dis. Reptr. 58:342-345.

REDDY, M.V. and NENE, Y.L. 1978. Screening of *Cicer* spp. for resistance to Ascochyta blight. Page 305 *in* Proc. of 3rd Int. Congress of Plant Path. August 1978, Munich, West Germany (Abstr.).

REDDY, M.V. and NENE, Y.L. 1979. A case for induced mutation in chickpea for Ascochyta blight resistance. Pages 398-408 *in* Proc. of the Symp. on the Role of Induced Mutations in Crop Improvement. Osmania University, Hyderabad, India.

REDDY, M.V. and SINGH, K.B. 1980. Effect of inter-row spacing on the reaction of chickpea lines to Ascochyta blight. International Chickpea Newsletter 3:12-13.

REDDY, M.V., NENE, Y.L. and SINGH, K.B. 1980. Field screening of chickpeas for resistance to Ascochyta blight. International Chickpea Newsletter 2:13-15.

SATTAR, A. and HAFIZ, A. 1957. A practical method of inoculating gram crop with gram blight fungus on a field scale. Pages 1-2 *in* Proc. Third Pakistan Sci. Cong.

SINGH, K.B., HAWTIN, G.C., NENE, Y.L. and REDDY, M.V. 1981. Resistance in chickpea to Ascochyta blight. Plant Dis. 65:586-587.

VEDYSHEVA, R.G., 1966. Infection of chickpea with *Ascochyta rabiei* in infected ground. Zap. Voronezh, sel'-Khoz. Inst. 32:275-281.

VIR, S. and GREWAL, J.S., 1974. Physiologic specialization in *Ascochyta rabiei*, the causal organism of gram blight. Indian Phytopathol. 27:355-360.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Evidence of Physiologic Races in *Ascochyta rabiei* of Chickpea

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Blight caused by *Ascochyta rabiei* (Pass.) Lab. is of major importance in areas where high humidity or rainfall occurs during the growing season of chickpea. The disease has been reported from India (Butler 1918), Bulgaria (Atanasoff and Kovacevski 1929), Morocco (Labrousse 1930), France (Labrousse 1931), Romania (Savulescu 1932), Greece (Sarejanni 1929), USSR (Pavlova 1935), Iran (Zalpoor 1963), Tanzania (Wallace 1948), Israel (Halfon-Meiri 1970) and Canada (Morrall and McKenzie 1974). Blight was first observed in 1911 (Butler 1918) in the North Western Frontier Province of India. Luthra and Bedi (1932) and Sattar (1933, 1934) worked out the cause and mode of perpetuation of the disease.

Variation in *Ascochyta rabiei*

Luthra *et al.* (1939) reported six different forms of *A. rabiei*, namely, A, B, C, D, E and F. Forms B, D, E and F which were biologically identical, differed from form C morphologically while form A was non-pathogenic. Aujla (1964) reported differences in cultural characters and pathogenic behavior of 11 isolates of *Phyllosticta rabiei* on different varieties of chickpea. Later, Bedi and Aujla (1969) suggested that the possible existence of physiologic races must be kept in view while testing breeding material for resistance to chickpea blight.

Kaiser (1973) reported that isolates of *A. rabiei* from India, Iran, Turkey and Pakistan varied greatly in growth rate, sporulation and colony appearance. He further observed that in inoculation studies there appeared to be differences in pathogenicity to different chickpea lines in the isolates of the pathogen from India, Iran, Turkey and West Pakistan. Vir and Grewal (1974) reported the existence of two physiologic races and one biotype of *A. rabiei* from India. Grewal (1975) wrote a comprehensive review on ascochyta blight of chickpea.

Later Nene *et al.* (1978) published an annotated bibliography on diseases of chickpea, including ascochyta blight.

Mycosphaerella rabiei Kovacevski, the perfect state of *Ascochyta rabiei* has been reported from Bulgaria by Kovacevski (1936) and from Greece by Zachos *et al.* (1963). It has not been reported from any other country, either in nature or in culture. This is probably the reason that we have relatively less variability in this pathogen.

Luthra *et al.* (1941) tested 392 lines and found three lines from USA, namely, Pois chich Nos. 4732, 199 and 281, which showed a high degree of resistance to *A. rabiei* under varying environmental conditions. For easy reference these lines were named F 8, F 9 and F 10, respectively. Infection was observed in traces on F 8 with faint, superficial lesions without pycnidia. Line F 8, being high yielder and blight resistant, was distributed to the farmers for cultivation in blight-affected areas. However, F 8 was susceptible to wilt. Therefore, Ahmad *et al.* (1949) released a cultivar C 12-34 (progeny of a cross between F 8 X Pb 7) as resistant to blight and tolerant to wilt. Cultivar C 12-34 lost its resistance to blight in 1950-51. A new cultivar C 235 (cross between F 8 and a high-yielding local chickpea cultivar) was developed and distributed to farmers (FAO 1963). This cultivar also lost resistance to blight in the epiphytotic year of 1968, probably due to the appearance of a new race of the pathogen (Grewal 1969). Keeping in view the variation in *A. rabiei* and breakdown of resistance in cultivar C 235, investigations were undertaken to determine the existence of physiologic races in the pathogen.

Experiments on Physiological Races

Two hundred and sixty-eight isolations were made from diseased leaves, stems and pods of chickpea collected from different lines and cultivars from many localities of the northern states of India during the epiphytotic of 1968. The isolates were purified and maintained on Potato-dextrose agar (potato 250g; agar 20 g; water 1000 ml) at 25°C, and were named according to the locality from where they were collected. They were grown on Richards's agar in culture tubes. On the basis of growth and sporulation, the isolates were grouped into 13 forms. One representative isolate from each form was taken and its pathogenicity confirmed on susceptible cultivar Pb 7. The above 13 forms were then grown on sterilized Richards's agar in Petri dishes (25 ml per plate). They were inoculated in the center with 5-mm disc of *A. rabiei* culture (15-day old) and incubated for 3 weeks at 25°C. The data on growth rate, colony color, pycnidial formation and size of pycnidia are given in Table 1.

Isolates G-31, G-51, G-52, L-24, L-60 and R-21 were relatively fast growing with fair amount of sporulation (Table 1). Colony color was light pink and the size of pycnidia relatively smaller than in isolates J 101, G-5, D-30, L-1, L-11,

Table 1
Cultural characteristics of different isolates of *A. rabiei.*

Isolates[1]	Line	Colony Diameter (mm)	Colony Color	Sporulation[2]	Size of pycnidia (mm)
G-31	G24	55	Light pink	++	159 x 130
G-51	C235	52	– do –	++	160 x 135
G-52	F8	51	– do –	++	151 x 139
L-24	C235	55	– do –	++	168 x 143
L-60	Galban	54	– do –	++	162 x 138
R-21	Pb7	54	– do –	++	155 x 141
J-101	Pb7	44	Dark brown	+++	240 x 235
G-5	EC 26435	41	– do –	+++	252 x 224
D-30	I-13	42	Mousey grey	+++	163 x 143
L-1	EC 26446	39	Buffy brown	++++	164 x 149
G-20	V138	40	– do –	++++	196 x 175
G-32	C168	38	Dark brown	++++	160 x 142

1. Isolate codes (the letter stands for location): G=Gurdaspur, L=Ludhiana, J=Jullundur and D=Delhi.
2. Sporulation ratings: ++ poor, +++ good, ++++ abundant.

G-20 and G-32 which had slow growth, good to abundant sporulation and slightly bigger pycnidia.

Physiologic Specialization Studies

Chickpea plants of 14 cultivars were grown in 20-cm earthern pots in five replications. After germination, five plants per pot were allowed to grow for 40 days. The inoculum of *A. rabiei* was multiplied on chickpea meal agar (chickpea meal 40 g; agar-agar 20 g; distilled water 1000 ml). Ten-day old cultures of each isolate were taken from the above media and a spore suspension (10×10^3 spores/ml) was prepared in sterilized distilled water separately for each isolate. The spore suspension thus prepared for each isolate was sprayed on 40-day old plants of all 14 cultivars separately. The inoculated plants were kept in chambers for 48 hours. Disease symptoms started appearing 1 week after inoculation. The final data regarding stem and foliage infection were recorded 3 weeks after inoculation. The following 1-9 scale was used for disease rating:

Disease grade	*Leaf and stem infection*
1	No infection (highly resistant)
3	Few minute lesions on stem and/or up to 5% foliage infection (resistant)

5	Stem lesions common, 2 to 6 mm long/or 5.1 to 25% foliage infection (moderately susceptible)
7	Stem lesions very common, bigger than 6 mm and/or 25.1 to 75% foliage infection (susceptible)
9	Stem lesions extensive, all young shoots and/or leaves killed (highly susceptible)

The data on disease grades produced by 13 isolates of *A. rabiei* on 14 cultivars are given in Table 2. It is evident that all isolates produced disease grades 7 and 9 on cultivars B-98, Attock, BN 3118, GC Bijapur, NP 100 and Pb 7 indicating that they are susceptible to *A. rabiei*. The remaining eight cultivars showed differential disease reaction to various isolates.

In order to illustrate the point of physiologic specialization or races in *A. rabiei*, the results obtained have been summarized in Table 3. The fast-growing and less-sporulating isolates G-31, G-51, G-52, R-21, L-24 and L-60 forming race 1 produced disease grades 1 and 3 on cultivars I-31, EC 26435 and C 235. On the other hand, the slow-growing, more-sporulating isolates L-1, L-11, G-5, G-20, G-32 and D-30 forming race 2 produced disease grades 5 and 7 on the above three cultivars. Isolate J 101 giving disease grade 3 on cultivars I-13 and C 235 and grade 5 on EC 26435 was designated as biotype of race 2. Race 2 appears to be a new race because the old resistant cultivar C 235 is susceptible to this race.

In order to locate more sources of resistance,well known blight-resistant lines and cultivars such as C 727 from Pakistan (Aziz 1962), "Bulgarian" from Israel (Solel and Kostrinski 1964), two hybrids VIR 32 and K 279 from USSR (Vedysheva 1966), line 12-074-06625 (I-13) from Iran (Kaiser 1972), lines EC 26414, EC 26435 and EC 26446 from Israel, Galben Cafai from Rumania and V 138 from Mexico (Sandhu 1972) were screened for resistance to more virulent race 2 of *A. rabiei* at New Delhi under artificial epipytotic conditions (Grewal and Vir 1974). The data are given in Table 4. All genotypes except 1528-1-1 were found to be moderately susceptible to susceptible (disease grades 5 and 7) to race 2 of *A. rabiei*. Line 1528-1-1 from Morocco, however, did not get infected even with race 2 and was therefore graded as highly resistant.

Discussion

Luthra *et al.* (1939) reported cultural and morphological variations among six isolates of *A. rabiei*. In the present study, 268 isolates of *A. rabiei* were grouped into 13 forms. One representative each of the 13 forms was used in further studies. Relatively fast-growing and less sporulating isolates, G-31, G-51, G-52, R-21, L-24 and L-60, were less virulent. On the other hand, slow-growing and abundantly-sporulating isolates, J-101, D-30, L-1, L-11, G-5, G-20, G-32 and D-30, were more virulent. Kaiser (1973) reported that isolates of *A. rabiei* from

Table 2

Disease grades produced on 14 lines/cultivars by 13 isolates of *A. rabiei*.

Line/ Cultivar	Isolates												
	G–31	G–52	R–21	L–24	L–60	G–51	J–101	D–30	G–5	G–20	L–11	L–1	G–32
L13	1	1	1	1	1	1	3	5	5	5	5	5	5
EC 26435	3	3	3	3	3	3	5	5	5	5	5	5	5
C235	3	3	3	3	3	3	3	7	5	7	7	7	7
F8	3	3	3	5	5	5	5	7	7	5	5	7	7
C 1234	3	3	3	5	7	5	7	7	7	7	7	7	7
C 377	3	3	3	5	5	7	7	7	5	5	7	7	7
V136	5	5	5	5	7	5	7	3	3	3	3	7	7
O–612	5	5	5	5	7	5	7	7	7	7	7	7	7
B98	7	7	7	7	7	7	9	9	9	9	9	9	9
Attock	7	7	7	7	7	7	7	9	9	7	9	9	9
B.N. 3118	7	7	7	7	9	7	7	9	7	9	9	9	9
G.C. Bijapur	7	7	7	7	9	9	9	9	9	9	9	9	9
NP 100	9	9	9	9	9	9	9	9	9	9	9	9	9
PB 7	9	9	9	9	9	9	9	9	9	9	9	9	9

Table 3
Disease grades produced on three cultivars by 13 isolates.

Isolate	Isolated from chickpea line/cultivar	CULTIVARS		
		1-13	EC 26435	C 235
G-31	C24	1	3	3
G-51	C235	1	3	3
G-52	F8	1	3	3
R-21	Pb7	1	3	3
L-24	C235	1	3	3
L-60	Galben	1	3	3
J-101	Pb7	3	5	3
L-1	EC 26446	5	5	7
L-11	Pb7	5	5	7
G-5	EC26435	5	5	7
G-20	V138	5	5	7
G-32	C168	5	5	7
D-30	I-13	5	5	7

Table 4
Disease grades produced on promising lines/cultivars by race 2 of *A. rabiei*.

Line/Cultivar	Country of orig	Disease grade
1528-1-1	Morocco	1
12-074-06625	Iran	5
C 727	Pakistan	5
Bulgarian	Israel	5
EC 21629	– do –	5
EC 26414	– do –	5
EC 26435	– do –	5
EC 26446	– do –	5
F 8	India	7
C235	– do –	7
C1234	Pakistan	7
Galben	Rumania	7
V138	Mexico	7
VIR 32	USSR	7
K279	USSR	7

India and Iran were highly sporulating as compared with those from Turkey and West Pakistan. He also observed differences in virulence of the isolates on differential chickpea lines. However, he did not make any attempt to correlate sporulating capacity of an isolate to its pathogenicity.

To reduce losses by ascochyta blight disease, resistant cultivars were released from time to time. These have subsequently been found to succumb to the pathogen (FAO 1963; Grewal 1969) indicating the possible appearance of new virulent strains of the pathogen. The fact that a given cultivar performed well for some years before it succumbed to the pathogen indicates the slow appearance of new strains. This may be due to the absence of the perfect state of the pathogen in the main chickpea-growing regions of the world. Attempts to establish races of the pathogen were made by Aujla (1964). Pathogenic variation among isolates of the pathogen has also been reported by Kaiser (1973).

The studies carried out at New Delhi indicate that the 13 morphological forms of the pathogen could be distinguished as two pathogenic races on the basis of disease reaction produced on three chickpea cultivars. Resistant type of disease reaction was produced by cultivars I-13, EC 26435 and C 235 against race 1 represented by fast-growing and less-sporulating isolates mentioned above. These cultivars were, however, moderately susceptible to susceptible to slow-growing and more-sporulating isolates representing race 2, except isolate J-101 which incited resistant type of infection (disease grade 3) on cultivars I-13 and C-235, and was distinguished as a biotype of race 2.

Pathogenicity tests with 15 well known blight-resistant lines from all over the world against race 2 of the pathogen showed that all of them except the highly resistant line 1528-1-1 from Morocco were moderately susceptible to susceptible to race 2. The observation that cultivar C 235, previously thought to be resistant in India, was susceptible to race 2 indicates that race 2 is a newly evolved or introduced race of the pathogen. It is also probable that the highly sporulating isolate of *A. rabiei* reported by Kaiser (1973) from Iran may belong to race 2 of the pathogen. Some new blight-resistant lines have been identified in Bulgaria (Geneva and Matsov 1977; Radkov 1978) and Syria (Singh *et al.* 1981).

Summary

Occurrence of *Ascochyta rabiei* and its variations have been reported from chickpea-growing countries. In view of the breakdown of resistance in known ascochyta blight resistant cultivars of chickpea in India, studies were undertaken to find out physiologic specialization in the pathogen. Two hundred and sixty-eight isolates of *A. rabiei* were collected, purified and grouped into 13 forms. One representative isolate of each form was used for further studies. Six fast-growing and low-sporulating isolates gave a resistant type of reaction on cultivars I-13, EC 26435 and C 235 and constituted race 1 of the pathogen. Six other slow-

growing and abundantly-sporulating isolates induced moderately susceptible disease reaction on the above cultivars and constituted more virulent race 2. Isolate J 101 gave moderately susceptible reaction on line I-13 and was distinguished as a biotype of race 2.

Fourteen chickpea lines identified as resistant by different workers in the world were found to be moderately susceptible to race 2. Line 1528-1-1 from Morocco, however, showed resistant reaction to this race.

References

AHMED, T., HASANAIN, S.N. and SATTAR, A. 1949. Some popular methods of plant disease control in Pakistan. Agric. Pakist. 1:18-22.

ARIF, A.G. and JABBAR, A. 1965. A study of physiologic specialization in *Mycosphaerella rabiei* Kovacevski *Ascochyta rabiei* (Pass.) Lab., the causal organism of gram blight. W. Pakist. J. Agric. Res. 3 (2-3):103-121.

ATANASOFF, D. and KOVACEVSKI, I.C. 1929. (Parasitic fungi new for Bulgaria) First contribution. Bull. Soc. Bot. de Bulgaria Sofia 3:45-32.

AUJLA, S.S. 1964. Studies on II isolates of *Phyllosticta rabiei*, the causal agent of gram blight in the Punjab. Indian Phytopath. 17:83-87.

AZIZ, M.A. 1962. C727, a new blight-resistant gram variety for Barani areas. W. Pakist. J. Agric. Res. 1:165-166.

BEDI, P.S. and AUJLA, S.S. 1969. Variability in *Phyllosticta rabiei* (Pass.) Trot., the incitant of blight disease of gram in the Punjab. J. Res. Punjab agric. Univ. 6:103-106.

BUTLER, E.J. 1918. Fungi and Diseases in Plants. Thacker Spink & Co., Calcutta, India. pp. 244-251.

FAO 1963. Quarterly Report for Oct.-Dec. 1962 of the Plant Protection Committee for the South-east Asia and Pacific region, FAO Publication, Bangkok, Thailand. 15 pp.

GENEVA, D. and MATSOV, B. 1977. Comparative testing of introduced and local samples of chickpea. Rastenievdni Nauki 14:57-59.

GREWAL, J.S. 1969. Important fungal diseases of *Cicer arietinum* in India. Seminar on Pulse production. Karaj, Iran. pp. 35-40.

GREWAL, J.S. 1975. Ascochyta blight of Bengal gram. Pages 161-167 *in* Advances in Mycology and Plant Pathology. Prof. R.N. Tandon Birthday Celebration Committee, Indian Phytopath. Soc., New Delhi.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to Asochyta blight. Indian Phytopath. 27:643-645.

HALFON-MEIRI, A. 1970. Infection of chickpea seeds by *Ascochyta rabiei* in Israel. Plant Dis. Reptr. 54:442-445.

KAISER, W.J. 1972. Occurrence of three fungal diseases of chickpea in Iran. *Ascochyta rabiei*, *Stemphylium sarciniforme* and *Sclerotinia* sclerotiorum. Reporting service on plant diseases and pests. Plant Bull. FAO 20:74-78.

KAISER, W.J. 1973. Factors affecting growth, sporulation, pathogenicity and survival of *Ascochyta rabiei*. Mycologia 65:444-457.

KOVACEVSKI, I.C. 1936. The blight of chickpea, *Mycosphaerella rabiei* new species. Min. Agric. nat. Domanicus Sofia. 80 pp.

LABROUSSE, F. 1930. Anthracnose of chickpea (*Cicer arietinum* L.) Rev. Path. Veg. Ent. Agric. 17:174-177.

LABROUSSE, F. 1931 Anthracnose of chickpea. Rev. Path. Veg. Ent. Agric. 18:226-231.

LUTHRA, J.C. and BEDI K.S. 1932. Some preliminary studies in gram blight with reference to its control and mode of perennation. Indian J. agric. Sci. 2:499-515.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1939. Variation in *Ascochyta rabiei* (Pass.) Lab., the causal fungus of blight of gram (*Cicer arietinum*). Indian J. agric. Sci. 9:791-806.

LUTHRA, J.C., SATTAR A. and BEDI, K.S. 1941. Determination of resistance to blight disease (*Mycosphaerella rabiei* = *Ascochyta rabiei*) in gram types. Indian J. agric. Sci. 11:249-264.

MORRALL, R.A.A. and McKENZIE, D.L. 1974. A note on the inadvertent introduction to North America of *Ascochyta rabiei*, a destructive pathogen of chickpea. Plant Dis. Reptr. 58:342-345.

NENE, Y.L., MENGISTU, A., SINCLAIR, J.B. and ROYSE, D.J. 1978. An annotated bibliography of chickpea diseases 1915-1976. ICRISAT, Patancheru, A.P., India.

PAVLOVA, A. 1935. Varieties of gram resistant *Ascochyta*. Bull. Appl. Bo. Leningrad. Ser. A. 14:43-45.

RADKOV, P. 1978. Biological and economic properties of some new varieties of chickpea. Rastenievdni Nauki 15:81-87.

SANDHU, T.S. 1972. New sources of resistance to gram blight disease, *Ascochyta rabiei*. Madras agric. J. 59:41.

SAREJANNI, J.A. 1939. Annotated list of fungi encountered on cultivated plants in Greece. Ann. Inst. Phytopath. Benaki 3:41-66.

SATTAR, A. 1933. On occurrence, perpetuation and control of gram (*Cicer arietinum* L.) blight caused by *Ascochyta rabiei* (Pass.) Lab. with special reference to Indian conditions. Ann. Appl. Biol. 20:612-632.

SATTAR, A. 1934. A comparative study of fungi associated with blight disease of certain cultivated leguminous plants. Trans. Br. Mycol. Soc. 18:276-301.

SAVULESCU, T. 1932. Phytosanitary conditions in Romania during the year 1930-31. Inst. Cerc. Agron. al. Romaniei Publ. 8:31.

SINGH, K.B., HAWTIN, G.C., NENE, Y.L. and REDDY, M.V. 1981. Resistance in chickpeas in *Ascochyta rabiei* (Pass.) Lab. Plant Dis. 65:586-587.

SOLEL, Z. and KOSTRINSKI, J. 1964. The control of Ascochyta anthracnose of chickpea. Phytopath. Mediterrance 3:119-120.

VEDYSHEVA, R.G. 1966. Infection of chickpea with *Ascochyta rabiei* in infected ground. Zap. Voronezh. Sel. Khosz. Inst. 32:275-281.

VIR, S. and GREWAL, J.S. 1974. Physiologic specialization in *Ascochyta rabiei*, the causal organism of gram blight. Indian Phytopath. 27:355-360.

WALLACE, G.B. 1948. Annual report, 1947. Department of Agriculture, Tanganyika. 3 pp.

ZACHOS, D.G., PONEGOPOVIOS, C.G. and MAKRIS, S.A. 1963. Researches on the biology, epidemology and the control of anthracnose of chickpea. Annls. Inst. Phytopath. Benaki, N.S. 5:167-192.

ZALPOOR, N. 1963. *Mycosphaerella rabiei* Kovacevski *Ascochyta rabiei* (Pass.) Lab. Ent. Phytop. Appl. Tehran 21:10-12.

Discussion

H.C. Weltzien

Has anybody worked on the perfect stage of the fungus and studied the pathogenic variability of single ascospore isolates?

J.S. Grewal

The work can be done only on knowing the conditions which help the perfect stage formation of *Ascochyta rabiei*. We have not worked on the perfect stage of the fungus. It will be very useful to study the variability in the ascospore isolates.

Y.L. Nene

About variability in the pathogen, I suggest that we look at single spore cultures from a single pycnidium. I have a feeling that we might detect variation there. We at ICRISAT have recently initiated some studies on this aspect.

J.S. Grewal

I agree with Dr. Nene that we should study single spore cultures from single pycnidium as well as single spore cultures from pycnidia formed by its side.

R. Pieters

Have you been able to identify resistance genes?

J.S. Grewal

Our studies in collaboration with breeders indicate that resistance is dominant and is controlled by a single gene.

R. Pieters

Do you think that the variability of *Ascochyta rabiei* is so great that rapid breakdown of vertical resistance can be expected?

J.S. Grewal

Breakdown of resistance has been observed in cultivars C12-34 and C235, twice in the past. Therefore, we should be prepared to accept such situations in the future. I think there is variability in the pathogen which can break down the resistance even in coming years.

M.V. Reddy

The breakdown of resistance in India and Pakistan is a bit confusing. Originally F8 was resistant and when it lost its resistance, C12-34 was developed using the same source. When C12-34 lost its resistance, C235 was developed using again F8. How does one expect to develop new resistant cultivars from the old defeated gene?

J.S. Grewal

Breeders thought that the cultivars had lost the purity. Therefore they had no alternative but to go back and to cross with the original source of resistance (i.e., F8) available with them. The new sources of resistance were identified by us in 1974. The new sources of resistance are now being used in breeding for new cultivars.

M.V. Reddy

Which are more ideal criteria for picking up races; different locations, different lines or different types of symptoms from different plant parts?

J.S. Grewal

There are more chances of picking up a new race of the pathogen if isolates are made from diseased plants of cultivars which have been reported to be resistant in one country and susceptible in another. It will also be very useful to make isolations from different locations and various parts of diseased plants to get as much variation as possible.

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International Screening of Chickpea for Resistance to Ascochyta Blight

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A joint contribution from ICARDA and ICRISAT centers

Blight caused by *Ascochyta rabiei* (Pass.) Lab. in chickpea (*Cicer arietinum* L.) is the major disease problem in West Asia, North Africa, South and East Europe, Pakistan and parts of India. The crop can be completely devastated in epiphytotic years. The best control measure is through resistant cultivars. Previous attempts to develop resistant cultivars yielded temporary and limited success mainly due to lack of durable sources of resistance. Therefore, a systematic search for durable sources of resistance in kabuli and desi germplasm maintained at ICARDA and ICRISAT centers, respectively, was initiated. Lines identified at ICARDA have been tested in blight endemic countries through Chickpea International Ascochyta Blight Nursery (CIABN) since 1978/79. The results of the screening at Tel Hadya and multilocation testing are reported in this paper. The need for continued effort by international centers and national programs in combating the problem is emphasized.

Screening of Germplasm at ICARDA

Kabuli Germplasm

Following the screening technique described by Singh *et al.* (1981), 3367 kabuli germplasm lines maintained at ICARDA Center were screened between 1978 and 1981. In the initial screening, 50 seeds of each line were planted in a single 5-m long row, spaced 45-65 cm apart. Lines found resistant/tolerant were reevaluated in subsequent seasons for further confirmation and purification.

The summary of the results of screening is presented in Tab. 1. No line rated 1 or 2 on a 1-9 scale. Eighteen and four lines were rated 3 and 4, respectively, and were considered resistant (0.65%). Forty-three lines showed tolerant reaction and

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Table 1
Summary of results of screening of chickpea kabuli germplasm for resistance to ascochyta blight at ICARDA, Syria.

Disease rating	No. of entries.	% of total entries
1	0	0.0
2	0	0.0
3	18	0.5
4	4	0.1
5	43	1.3
6	17	0.5
7	859	25.5
8	14	0.4
9	2412	71.6
Total	3367	100.0

1 = highly resistant; 5 = tolerant; 9 = highly susceptible.

the remaining were rated moderately to highly susceptible. Most of the resistant lines originated from the USSR, Turkey and Afghanistan (Tab. 2).

Desi Germplasm

A total of 6005 desi germplasm lines maintained at ICRISAT Center including 37 available at ICARDA were screened during the 1979/80 and 1980/81 seasons. The summary of results is presented in Tab. 3.

A total of 13 and 200 lines were given a ring of 2 and 3, respectively, and are considered as resistant (3.54%). Four hundred and forty-two lines (7.36%, showed 4 rating (moderately resistant), 253 lines (4.21%) showed tolerant reaction and the remaining had susceptible to highly susceptible ratings. The lines with 2 and 3 ratings are listed below:

Rating 2: ICC 3606, 3912, 3916, 3918, 3919, 3921, 3932, 3940, 3996, 4107, 4192, 4472, 4475.

Rating 3: ICC 12, 76, 94, 124, 280, 202, 369, 478, 529, 601, 607, 623, 641, 643, 652, 657, 665, 697, 716, 740, 758, 799, 800, 801, 986, 1062, 1069, 1084, 1085, 1087, 1091, 1093, 1102, 1106, 1117, 1121, 1136, 1168, 1177, 1234, 1301, 1400, 1414, 1416, 1467, 1468, 1472, 1525, 1532, 1591, 1654, 1711, 1754, 1757, 1762, 1772, 1809, 1854, 1871, 1877, 1881, 1883, 1903, 1905, 1947, 1963, 1973, 1983. ICC 2117, 2160, 2165, 2232, 2256, 2270, 2342, 2364, 2534. ICC 3127, 3141, 3152, 3221, 3377, 3404, 3422, 3424, 3481, 3509, 3540, 3542, 3578, 3580,

3597, 3598, 3599, 3601, 3623, 3626, 3627, 3634, 3642, 3737, 3781, 3787, 3795, 3796, 3800, 3807, 3842, 3859, 3863, 3871, 3880, 3958, 3962, 3969, 3986, ICC 4000,4006,4014, 4018, 4020, 4030, 4033, 4038, 4045, 4055, 4061, 4063, 4065, 4066, 4074, 4075, 4087, 4092, 4093, 4111, 4112, 4116, 4168, 4169, 4174, 4176, 4177, 4178, 4179, 4181, 4187, 4208, 4222, 4223, 4226, 4231, 4241, 4293, 4294, 4315, 4319, 4324,4351, 4361, 4362, 4369, 4370, 4392, 4431, 4616, 4819, 4828, 4950, 4987.ICC 5033, 5035, 5124, 5127, 5173, 5566, 5573, 5766, ICC 6067, 6103, 6250, 6304, 6306, 6330, 6336, 6373, 6813, 6942, 6981, 6989. ICC 7300, 7000, 7002, 7513, 7520, Aug. 480, NEC 1382, NEC 1256, NEC 1431.

Table 2
Chickpea kabuli germp' sm lines found resistant to ascochyta blight at ICARDA, Syria.

ILC No.	Rating	Country of Origin
72	3	Spain
182	3	USSR
183	3	USSR
187	3	USSR
191	3	USSR
194	3	USSR
200	3	USSR
201	3	USSR
202	3	USSR
236	3	Afghanistan
482	3	Turkey
484	3	Turkey
2380	3	USSR
2506	3	Unknown
2548	3	USSR
2956	3	USSR
3001	4	Afghanistan
3279	3	USSR
3340	4	India
3342	4	Afghanistan
3346	3	USSR
3400	3	ICARDA

About 84% resistant lines originated from Iran and 11% from India (Tab. 4).

The seed color of the majority of resistant lines (87.84%) was black, and a few had brown and yellow colors (Tab. 5). But all black coloured chickpeas were not resistant (Tab. 6).

Table 3
Summary of results of screening chickpea desi germplasm lines for resistance to ascochyta blight at ICARDA, Syria.

Disease rating	1979–80 screening	1980–81 screening	Total entries	% of total entries
1	0	0	0	0.00
2	0	13	13	0.2
3	33	167	200	3.3
4	0	442	442	7.4
5	35	218	253	4.2
6	0	76	76	1.3
7	115	131	246	4.1
8	0	20	20	0.3
9	1818	2937	4755	79.2
	2001	4004	6005	100.0

1 = highly resistant; 5 = tolerant; 9 = highly susceptible.

Table 4
Origin of chickpea desi germplasm lines found resistant to ascochyta blight at ICARDA, Syria.

Country of origin	No. of resistant lines	% of resistant entries
Iran	534	84.3
India	73	11.3
Turkey	9	1.4
Pakistan	5	0.7
USSR	4	0.6
Mexico	3	0.4
USA	3	0.4
Afghanistan	1	0.1
Morocco	1	0.1
Total	633	100.0

Cicer Wild Species

Thirteen accessions of seven *Cicer* species were tested during 1979/80. Three accessions of *C. pinnatifidum*, *C. montbretti* and *C. judaicum* were found to be free from infection. Accessions of other species, *C. yamashitae*, *C. bijugum*, *C. cunneatum* and *C. reticulatum* showed tolerant to highly susceptible reactions.

Table 5
Seed color of desi germplasm lines found resistant to ascochyta blight at ICARDA, Syria.

Seed color	No. of entries	% of total resistant entries
Black	573	87.5
Brown	43	6.6
Yellow	17	2.6
Light brown	10	1.5
Dark brown	7	1.0
Yellow brown	5	.7
Total	655	100.0

Table 6
Relationship between seed color and resistance to ascochyta blight of chickpea.

Seed color	No. of lines tested	No. of lines found resistant	% of lines tested
Black	862	573	66.4
Yellow brown	219	5	2.2
Brown	1995	43	2.1
Yellow	822	17	2.0
Dark brown	382	7	1.8
Light brown	549	10	1.7

International Screening

Chickpea International Ascochyta Blight Nursery (CIABN)

The CIABN was initiated during 1978/79 with the objectives of identifying sources of resistance/tolerance to ascochyta blight in different countries of the region, identifying sources of resistance across locations and seasons, and collecting information on the existence of races of the pathogen. The nursery was continued during the 1979/80 and 1980/81 seasons.

The entries in the CIABN mainly consisted of those found resistant at ICARDA and some in propagator screening at ICRISAT. A few of the lines reported resistant by earlier workers for which seed was available were also included. The nursery comprised 40, 50 and 40 resistant/tolerant entries during 1978/79, 1979/80 and 1980/81, respectively. The entries included in the nurs-

ery originated from the USSR, Spain, Turkey, Iran, Tunisia, USA, Afghanistan, Ethiopia, India, Morocco and Pakistan.

During 1978/1979, 30 seeds of each entry were supplied to be sown in a single 3-m long row. During the following 2 years sufficient quantity of seed of each entry was supplied to be sown in 4-m long rows in two replications. The seed of a susceptible check (ILC 1929) was furnished to be sown after every two test entries, to serve as a spreader-cum-indicator rows.

The cooperators were advised wherever possible to sow the nursery during the winter in an endemic area. Debris method of inoculation was suggested and if the level of infection was insufficient, spraying with a spore suspension prepared from infected plants was indicated. A 1-9 rating scale of Singh *et al.* (1981) was suggested for scoring the lines.

During 1978/79, 13 sets of the nursery were distributed. The results from 5 of 11 locations that returned data were worth considering. During 1979/80, 26 sets were distributed. The results from 7 of 13 locations that returned data were worth considering. During 1980/81, 26 sets were distributed and results from six locations were received.

The results from 1978/79, 1979/80 and 1980/81 tests are presented in Tab. 7, Tab. 8 and Tab. 9, respectively.

1978/79: Seven lines, namely, ILC 191, 192, 195, 200, 201, 202 and NEC 138-2 were rated resistant (3 rating) at all the five locations. Other promising lines (5 rating or less across locations) were ILC 182, 183, 194, 482, NEC 2388 NEC 138-1. Only one line, ILC 618, showed a susceptible reaction across locations. Others showed resistant reactions at some locations and susceptible at others.

1979/80: Three lines, namely, ILC 191, 202 and 3279 were rated resistant at all seven locations. Other promising lines were ILC 194, 200, 201, NEC 138-2 and 1256. Ten lines showed a susceptible reaction across locations.

1980/81: Eleven lines, namely, ILC 72, 191, 194, 196, 484, 2380, 2956, 3279, ICC 1903, 5127 and PCh 15 showed resistant reaction across six locations. Twelve lines, viz. ILC 182, 183, 200, 201, 202, 2548, NEC 138-2, ICC 2160, 7513, 7514, 7520 and PCh 128 were found promising. None of the lines was found susceptible across locations.

Syria. On the basis of 3 years testing at two locations, 16 lines, namely, ILC 72, 182, 183, 191, 194, 200, 201, 202, 482, 2380, 2548, 2956, 3279, 77 Ms 73022-2, PCh 15 and 128 were found resistant. Fourteen lines, viz. ILC 195, 236, 244, 248, NEC 138-2, 1256, G 543, 549, ICC 280, 1903, 2160, 4935, 5127 and 7513 were found promising.

Turkey. Six lines, namely, ILC 191, 200, 201, 202, 2380 and 3279 were found

Table 7
Reaction of entries of Chickpea International Ascochyta Blight Nursery, 1978–79.

Entry		Origin	Rating on 1–9 Scale					
			SYRIA		ALGERIA	TURKEY		
			Tel Hadya	Lattaquieh	Sidi-Bel-Abbes	Eskishehir	Izmir	Mean
ILC	105	Spain	9	5	5	7	7	6.6
	182	USSR	1	3	1	5	5	2.8
	183	USSR	1	3	1	5	3	2.6
	184	USSR	7	3	5	9	7	6.2
	189	USSR	5	3	5	7	5	5.0
	190	USSR	7	3	1	7	5	4.6
	191	USSR	1	3	3	3	4	2.8
	192	USSR	1	3	3	3	3	2.6
	193	USSR	7	7	3	5	5	4.6
	194	USSR	1	3	1	5	3	2.6
	195	USSR	3	3	3	3	3	3.0
	197	USSR	5	3	9	3	7	5.4
	200	USSR	3	3	1	3	3	2.6
	201	USSR	1	1	1	3	2	1.6
	202	USSR	3	3	1	3	3	2.6
	210	USSR	3	5	1	5	7	4.2
	212	USSR	5	5	3	7	7	5.4
	236	USSR	3	5	3	7	6	4.8
	244	USSR	3	5	3	9	7	5.8
	248	USSR	3	5	1	9	7	5.4

Table 7. Contd.

Entry		Origin	Rating on 1–9 Scale					
			SYRIA		ALGERIA	TURKEY		
			Tel Hadya	Lattaquieh	Sidi-Bel-Abbes	Eskishehir	Izmir	Mean
ILC	249	USSR	5	3	7	7	7	5.8
	430	Iran	5	7	9	7	9	7.4
	432	Turkey	3	3	3	5	5	3.8
	484	Turkey	1	3	9	7	5	5.0
	611	Tunisia	9	7	3	7	9	9.0
	616	Tunisia	9	7	1	9	9	7.0
	618	Tunisia	9	9	9	9	9	9.0
	1255	USA	3	5	9	9	8	6.8
	1287	USA	3	5	9	9	6	6.4
	1276	USA	7	5	1	9	6	5.6
NEC	659	Iran	7	5	1	7	7	5.4
	2388	USA	3	5	5	5	5	4.6
	138–1	USSR	5	5	5	5	3	4.6
	138–2	USSR	3	3	3	3	3	3.0
	1256	Iran	3	5	3	7	6	4.8
77Ms	73022–2	ICARDA	3	3	1	7	6	4.0
	73131–11	ICARDA	5	5	3	9	9	6.2
	73131–12	ICARDA	7	5	3	7	9	6.2
	73131–13	ICARDA	7	5	3	7	5	5.2
	73132–14	ICARDA	5	3	3	9	9	5.8
Mean rating of susceptible check			9	9	8.4	9	9	

1= highly resistant; 5= tolerant; 9 = highly susceptible.

Table 8
Reaction of entries of Chickpea International Ascochyta Blight Nursery, 1979–80.

Entry		Origin	Rating on 1–9 Scale							Mean
			SYRIA		LEBANON	TURKEY	ALGERIA	PAKISTAN		
			Tel Hadya	Lattaquieh	Terbol	Izmir	S.B.A.[1]	Islamabad	Faisalabad	
ILC	182	USSR	3	2	3	4	1	5	7	3.6
	183	USSR	3	4	3	5	2	5	8	4.3
	190	USSR	6	7	3	8	3	9	9	6.4
	191	USSR	3	3	3	4	3	1	4	3.0
	192	USSR	8	6	5	5	3	1	7	5.0
	194	USSR	3	5	3	5	2	1	5	3.4
	195	USSR	5	3	3	6	3	1	4	3.6
	200	USSR	3	3	3	3	1	1	6	2.9
	201	USSR	3	3	3	3	3	1	5	3.0
	202	USSR	3	1	3	4	2	1	4	2.6
	210	USSR	5	6	3	8	3	9	9	6.1
	215	USSR	7	6	3	8	1	9	9	6.1
	248	USSR	6	5	3	8	2	9	9	6.0
	430	Iran	9	9	8	9	5	9	9	8.3
	482	Turkey	4	5	3	8	1	3	9	4.7
	616	Tunisia	9	9	9	9	5	9	9	8.4
	618	Tunisia	9	9	9	9	7	9	9	8.7
	1757	Afghanistan	5	8	3	6	3	9	9	5.9
	2380	Unknown	3	3	3	3	3	1	9	3.6
	2459	India	5	7	3	6	3	3	8	5.0
	2582	Unknown	6	7	3	9	4	9	9	6.7
	2585	Ethiopia	6	7	3	9	3	9	9	6.6
	2919	Afghanistan	5	7	4	6	4	9	9	6.3
	3000	Unknown	7	8	5	7	4	8	9	6.9
	3279	Tunisia	3	3	3	3	3	1	2	2.6
	4131	Unknown	5	7	3	6	3	4	6	4.9

Table 8 Contd.

Entry		Origin	Rating on 1–9 Scale							Mean
			SYRIA		LEBANON	TURKEY	ALGERIA	PAKISTAN		
			Tel Hadya	Lattaquieh	Terbol	Izmir	S.B.A.[1]	Islamabad	Faisalabad	
77Ms	73022–2	ICARDA	4	6	3	6	3	9	9	5.7
77Ms	73131–12	ICARDA	7	8	4	9	3	9	8	6.9
NEC	138–2	USSR	5	3	3	5	2	1	7	3.7
	1256	Iran	5	5	3	5	3	2	5	4.0
ICC	150	ICRISAT-India	9	9	9	9	6	9	9	8.6
	280	ICRISAT-India	5	5	3	6	2	9	9	5.6
	931	ICRISAT-India	9	9	9	9	8	9	9	8.9
	1009	ICRISAT-India	9	9	9	9	9	9	9	9.0
	1465	ICRISAT-India	9	9	9	9	9	9	9	9.0
	1911	ICRISAT-India	9	9	8	9	9	9	9	8.9
	2153	ICRISAT-India	9	9	9	9	8	9	9	8.9
	2156	ICRISAT-India	9	9	9	9	6	9	9	8.6
	2160	ICRISAT-India	3	3	2	5	3	2	9	3.9
	2232	ICRISAT-India	5	7	3	6	3	6	9	5.6
	3259	ICRISAT-India	9	9	9	9	9	9	9	9.0
	3277	ICRISAT-India	9	9	9	9	9	9	9	9.0
	3330	ICRISAT-India	9	9	9	9	9	9	9	9.0
	4935	ICRISAT-India	3	3	3	6	3	9	9	5.1
	6067	ICRISAT-India	5	3	3	6	3	9	9	5.4
	7513	ICRISAT-India	5	5	3	6	2	3	8	4.6
	7514	ICRISAT-India	5	7	3	6	3	3	9	5.1
	7520	ICRISAT-India	5	7	3	6	3	3	9	5.1
G	543	ICRISAT-India	5	5	3	7	5	6	8	5.6
G	549	ICRISAT-India	5	5	3	7	3	6	8	5.7
Mean rating for susceptible check			9.0	9.0	9.0	7.6	9.0	8.9		

1. S.B.A. = Sidi-Bel-Abbes

Table 9
Reaction of entries of Chickpea International Ascochyta Blight Nursery, 1980–81.

Entry		Origin	Rating on 1–9 Scale							Mean
			SYRIA		PAKISTAN				LEBANON	
			Tel Hadya	Lattaquieh	Islamabad	Tarnab	Faisalabad	Lahore	Terbol	
ILC	72	Spain	3	3	3	3	3	3	3	3.0
	182	USSR	3	3	5	3	3	3	3	3.2
	183	USSR	3	3	3	3	5	3	3	3.2
	191	USSR	3	3	3	3	3	3	3	3.0
	194	USSR	3	3	3	4	3	3	3	3.1
	195	USSR	5	3	3	3	3	3	3	3.2
	196	USSR	3	3	4	3	3	3	3	3.1
	200	USSR	3	3	4	3	5	3	3	3.4
	201	USSR	5	3	5	3	5	3	3	3.8
	202	USSR	5	3	5	4	5	3	3	4.0
	215	USSR	7	3	8	7	7	7	3	6.0
	482	Turkey	3	3	6	5	6	6	3	4.5
	484	Turkey	3	3	3	4	4	4	3	3.4
	1695	Afghanistan	3	3	7	4	6	3	4	4.2
	1757	Afghanistan	4	3	7	5	7	5	3	4.9
	2380	Unknown	3	3	4	3	4	2	3	3.1
	2548	Unknown	3	3	4	3	5	4	3	3.5
	2555	Unknown	6	3	7	6	8	6	4	5.7
	2956	USSR	3	3	3	3	3	3	3	3.0
	3257	USSR	4	3	7	5	7	6	3	5.0
	3279	Tunisia	3	3	3	3	3	3	4	3.1
77Ms	73022–2	ICARDA	4	3	6	7	8	6	3	5.2
NEC	138–2	USSR	6	3	5	4	4	2	4	4.0
	1256	Iran	5	3	6	5	3	5	3	4.2
ICC	280	ICRISAT	5	3	8	6	8	5	3	5.4
	1903	ICRISAT	5	3	3	3	3	3	4	3.4

Table 9. Contd.

Entry		Origin	Rating on 1–9 Scale							Mean
			SYRIA		PAKISTAN				LEBANON	
			Tel Hadya	Lattaquieh	Islamabad	Tarnab	Faisalabad	Lahore	Terbol	
ILC	2160	ICRISAT	3	3	3	3	4	5	5	3.7
	2232	ICRISAT	5	3	3	5	9	5	3	4.7
	4131	Unknown	4	3	7	3	4	5	3	4.1
	4935	ICRISAT	3	3	7	5	6	5	3	4.5
	5127	ICRISAT	3	3	3	3	4	3	4	3.2
	6067	ICRISAT	3	3	7	6	7	5	3	4.8
	7513	ICRISAT	4	3	3	5	3	3	4	3.5
	7514	ICRISAT	4	3	3	4	3	3	5	3.5
	7520	ICRISAT	4	3	3	3	3	5	3	3.4
G	543	Punjab-India	3	3	7	5	7	7	4	5.1
	549	Punjab-India	3	3	7	5	5	5	4	4.5
AUG	480	Punjab-Pakistan	5	3	7	6	7	6	3	5.2
Pch	15	Morocco	3	3	3	3	2	2	3	2.7
	128	Morocco	3	3	3	3	4	5	4	3.5
Mean rating of the susceptible check			9	9	8	9	9	9	9	

1 = highly resistant, 5= tolerant, 9 = highly susceptible.

resistant for 2 years at two locations. Seven lines, namely, ILC 182, 183, 192, 193, 194, NEC 138-1 and ICC 2160 were found promising.

Algeria. A very large number of lines, some for 2 years and others for 1 year, were found resistant.

Pakistan. Ten lines, namely, ILC 72, 191, 194, 484, 2956, 3279, ICC 1903, 5127, 7514 and PCh 15 were found resistant for 1 to 2 years at two to four locations. Another 11 lines, viz. ILC 182, 200, 201, 202, 2380, 2548, NEC 138-2, ICC 2160, 7513, 7520 and PCh 128 were found promising.

Lebanon. Thirty-four lines were found resistant and two tolerant during 1979/80. Additional 12 lines were found to be promising.

A critical study of CIABN results from 1979 to 1981 revealed a differential reaction of certain genotypes with locations (Tab. 10). Two lines, ILC 1929 and ILC 3279 showed susceptible and resistant reactions, respectively, at all locations. The reaction of all the lines except ILC 215 at the two locations tested in Syria was the same. This line showed a susceptible reaction at all other locations but was resistant at Terbol in Lebanon and Sidi-Bel-Abbes in Algeria. ILC 484, which was resistant at all other locations, showed susceptibility at Sidi-Bel-Abbes in Algeria and Eskishehir in Turkey. ILC 484 was however resistant at Izmir in Turkey.

In Pakistan, the reaction of the lines at all four locations was found to be different. 77 Ms 73022-2 was susceptible at all locations and ILC 482 was resistant at Faisalabad. Others had variable reactions. The data reveal the presence of different races in 9 out of 10 locations tested and need further confirmation through laboratory testing.

Chickpea International Ascochyta Blight Nursery – Desi (CIABN-D)

Following the screening of 2000 ICRISAT desi (D) germplasm and the identification of 32 resistance sources during 1979/80 season, it was considered desirable to initiate a CIABN (D) with the same objectives as of CIABN.

The CIABN (D) comprised 32 entries most of which originated in India. For each entry, 40 seeds were furnished to be sown in a single 4-m row spaced 30-40 cm apart. The management of the nursery was the same as that of the CIABN.

Seven sets of the nursery were distributed to cooperators in Pakistan, Turkey, Lebanon and Syria. The results have been obtained from five locations. The disease development at Faisalabad in Pakistan was poor hence the results have not been considered.

The results are presented in Tab. II. Thirty lines were found resistant in Syria both at Tel Hadya and Lattaquieh. But only six of these lines, ICC 76, 607, 641,

Table 10
Differential reaction of some entries of CIABN (1979–81) with locations.

	SYRIA		LEBANON	ALGERIA	TURKEY		PAKISTAN			
	Tel Hadya	Lattaquieh	Terbol	Sidi-Bel-Abbes	Eskishehir	Izmir	Islamabad	Faisalabad	Tarnab	Lahore
ILC 1929	S	S	S	S	S	S	S	S	S	S
215	S	R	R	R		S	S	S	S	S
77Ms 73022–22	R	R	R	R	S	S	S	S	S	S
ILC 482	R	R	R	R	R	S	S	R	S	S
ILC 4935	R	R	R	R		S	S	R	S	R
ILC 484	R	R	R	S	S	R	R	R	R	R
ILC 2232	R	R	R	R		S	R	R	S	R
ILC 4131	R	R	R	R		S	S	R	R	R
ILC 3279	R	R	R	R	R	R	R	R	R	R

R = ratings of 1 to 5; S = ratings of 6 to 9.

Table 11
Reaction of the entries of Chickpea International Asco hyta Blight Nursery – Desi, 1980–81.

Entry		Origin	SYRIA		PAKISTAN	
			Tel Hadya	Lattaquieh	Islamabad	Tarnab
ICC	76	India	3	3	3	2
	94	India	4	3	6	7
	280	India	4	3	6	7
	292	India	5	3	7	7
	478	India	3	3	6	6
	607	Unknown	3	3	3	3
	641	India	3	3	3	4
	758	India	3	3	6	6
	799	India	4	3	6	5
	800	India	3	3	6	7
	801	India	3	3	6	6
	1062	Pakistan	4	4	6	7
	1069	Unknown	3	3	3	4
	1121	Iran	3	3	5	3
	1136	India	3	3	6	6
	1168	India	3	3	7	6
	1414	India	4	3	7	7
	1416	India	4	3	7	6
	1467	India	3	3	3	3
	1468	India	3	3	5	3
	1525	India	3	3	7	6
	1591	India	5	3	2	4
	1754	India	4	3	7	4
	1762	India	3	3	7	7
	1772	India	3	3	5	4
	1809	India	4	3	7	7
	1854	India	4	3	6	7
	1871	India	3	3	6	5
	1881	India	4	3	7	7
	1963	India	4	3	7	7
	1973	India	4	3	7	6
	1983	India	4	3	7	6

1069, 1467, 1591 were found resistant in Pakistan. Another three lines, ICC 1121, 1468 and 1772 were promising.

Multiple Disease Resistance

While it is true that ascochyta blight is the major disease in the Mediterranean region, the presence of other diseases, such as fusarium wilt, stunt (pea leaf-roll virus) and botrytis grey mold has been reported from several countries in the region (Nene 1981).

To identify lines with multiple disease resistance, the lines found resistant to wilt and stunt (pea leaf-roll virus) at ICRISAT Center were screened for resistance to blight during the 1980/81 season. The appearance of botrytis grey mold in epiphytotic form in Lahore (Pakistan) during the same season enabled a study of the reaction of entries in the CIABN and CIYT-W to this disease.

The results of screening for wilt, stunt, botrytis grey mold and ascochyta blight are presented in Tab. 12. G 543, which is resistant to wilt and stunt, showed tolerant reaction to blight. In addition, three wilt-resistant lines, GG 588, GG 663 and GG 688 showed tolerant/resistant reaction to blight. Seven of the stunt-resistant lines showed resistance to blight. Four blight-resistant lines showed resistance to grey mold under natural epiphytotic conditions in Pakistan.

Table 12
Reaction of chickpea wilt and stunt resistant lines to ascochyta blight at ICARDA, Syria.

Entry	Ascochyta blight	Wilt	Stunt	Botrytis grey mold
ILC 200	R	N	N	R
ILC 2380	R	N	N	R
NEC 138-2	R	N	N	R
ICC 5127	R	N	N	R
G 543	T	R	R	S
GG 588	T	R	S	N
GG 663	T	R	S	N
GG 668	R	R	S	N
ICC 57	T	S	T	N
ICC 690	T	S	R	N
ICC 1881	R	S	R	N
ICC 1963	R	S	R	N
ICC 2534	R	S	R	N
ICC 3133	R	S	R	N
ICC 4935	R	S	R	S
ICC 7003	R	S	R	N

R = resistant, T= tolerant, S = susceptible, N = not known.

Discussion

Fifty years ago, three pure lines of *Cicer arietinum* were reported to be completely resistant to ascochyta blight from North Africa (Anonymous 1931). Since then there have been many reports of resistant genetic material from India, Pakistan, Iran, Turkey, Syria, Morocco, North Africa, France, Bulgaria and the USSR. So far as many as 135 sources of resistance have been reported (Tab. 13).

Screening of 9372 kabuli and desi germplasm lines from 1978 to 1981 at ICARDA Center has helped to identify 677 additional resistant lines to ascochyta blight. Even though sufficient sources of resistance are available, screen-

Table 13
List of chickpea lines reported resistant/tolerant to ascochyta blight.

Year	Source/authors	Lines
1931	Anonymous	Two pure lines of *C. arietinum* var *album* and one pure line of *C. arietinum* var nigrum.
1938	Luthra *et al.*	Pois chiches Nos. 180, 199, 281. 4F32.
1938	Anonymous	Three cultivars from France.
1943	Luthra *et al.*	Natural hybrid No. 62–18.
1949	Anonymous	Lines 99/21, 21, 142.
1952	Hafiz	Pois chiches Nos. 4732, 199, 281 renamed as F8, F9 and F10 respectively.
1960	Bushkova	Kubauskii, 16; Krasnotkutskii, 195; Krasnogradskii, 1; Ustoichi-vyi, 2; Askokitous-toichiyyi, 1.
1962	Aziz	C 727
1962	Bedi and Athwal	C 235
1964	Solel and Kostrinski	Bulgarian
1966	Vedysheva	Dobrudzauskyi, Plovdiv 19.
1967	Aujla and Bedi	11/48–7, B.N. 3118, P-36, Broach G.G. pedapuram, Allock 234, 337, 172/3, 436, 84, 241/1.
1970	Radkov	Gbraztsov chiflik 6 (No. 180), Gbraztsov chiflik 7 (No. 307).
1972	Kaiser	1–13 (12–074–06625).
1972	Sandhu *et al.*	EC 21629, EC 26414, EC 26435 EC 26446
1974	Grewal and Vir	Selection P 1528–1–1, 1–13 (12–074–06625).
1974	Khil'ko	K 1459, K 1469, K 1488, K 1502
1976	Aslam *et al.*	AUG 480
1976	Eser	Code No. 72–012
1977	Ganeva and Matsov	Vars. Sovkhozuyi 14, Kubanskivi 199, VIR 32, No. 222, Resursi 216.
1978	Reddy and Nene	Four moderately resistant lines.
1978	Singh	Ejalben, EC 26414, 26435, 26446.
1979	Morocco Program (Pers. Commun.)	Pch 15, Pch 34, Pch 128.
1981	Singh *et al.*	55 lines
1981	Haq *et al.*	CM 68, C 72.

ing of the remaining collections of desi germplasm maintained at ICRISAT Center and future collections of the kabuli germplasm will be continued. The availability of a large number of resistant lines in desi and kabuli background should help breeders to develop resistant and high-yielding cultivars.

It was earlier believed that kabulis lack resistant genes to ascochyta blight but screening a large collection revealed many lines having a high level of resistance. However, it is worth noting that none of the extra large seeded kabulis had the desired level of resistances. Most of the resistant lines had small seed size. But is evident that desis (10.91%) have a higher proportion of resistance than the kabulis (0.65%).

Most of the resistance sources have their origin in the USSR, Iran, India, Afghanistan and Turkey, which are belived to be the primary and secondary centers of the origin of chickpea. The majority of the desi resistant lines was found to be black seeded originating from Iran. Kaiser (1973) also found most of the resistant lines to be black seeded in Iran. Additional search for sources of resistance in black-seeded types originating from Iran should result in greater success. More collections from the region on a priority basis is suggested before the landraces are replaced by new genotypes.

In the past, lines identified as resistant at one location were usually not tested out at other locations (Grewal and Vir 1974; Nene *et al.* 1979). A strong need is feit to collect all sources of resistance and test them at other locations to identify lines with a broad spectrum resistance. Also, a line may have become susceptible in its original habitat due to the emergence of a new race but it may still be resistant to the original race that may be prevalent elsewhere. For example, C 235, identified as resistant in India during 1962 is now found susceptible there (Bedi and Athwal 1962) but has shown resistance in Syria and some other places.

The international testing of resistant lines through CIABN helped in the identification of six lines, namely, ILC 72, 191, 194, 202, 3279 and PCh 15, resistant across locations and/or years. These lines seem to possess location/race nonspecific or broad spectrum resistance and should be very useful in the future breeding programs. Such lines were not available earlier. In addition, a large number of lines, such as ILC 182, 183, 200, 201, 2380 and ICC 1903 were found promising across locations and years.

The differential reaction of some lines at different locations strongly indicates the presence of races. Aujla (1964) and Bedi and Aujla (1969) have indicated the possible existence of races in *A. rabiei* in India. Later Vir and Grewal (1974) identified two races and a biotype. The present study indicates the variability in the blight pathogen in the wider geographic region.

Maximum effort has gone into tackling the blight problem in Pakistan since the early 1930s, yet the solution is nowhere near. It could be due to lack of either durable sources of resistance or sustained effort on the part of plant breeders. It is not only true for Pakistan but also for other parts of the world. In the Mediter-

ranean region where chickpea is spring-sown, the reliance on the part of most scientists and farmers so far has been on "avoidance" of the disease by sowing the crop towards the end of the rainy season rather than searching for resistant material. The identification of a large number of desi and kabuli lines with a very high degree of resistance in wide geographic regions and sustained breeding efforts by the international centers and national programs should result in the development of blight-resistant, high- yielding cultivars in the very near future.

Summary

During 1978-81, 3367 chickpea kabuli germplasm lines maintained at ICARDA Center were screened for resistance to ascochyta blight. Twenty-two of these (0.65%) lines were resistant: ILC 72, 182, 183, 187, 191, 194, 200, 201, 202, 236, 482, 484, 2380, 2506, 2548, 2956, 3001, 3279, 3340, 3342, 3346 and 3400. Screening of 6005 desi germplasm lines maintained at ICRISAT Center revealed 655 lines to be resistant to moderately resistant. The lines with rating 2 were ICC 3606, 3912, 3916, 3918, 3919, 3921, 3932, 3940, 3996, 4107, 4192, 4472 and 4475. Most of the kabuli resistant lines originated from the USSR, Turkey, Iran and Afghanistan, the regions believed to be the center of origin of chickpea. Most of the desi resistant lines originated from Iran, India, Turkey and Pakistan and were found to be of black-seed type. More search for resistance in black-seeded type from these regions may result in greater success.

The results of Chickpea International Ascochyta Blight Nursery (CIABN) conducted for 3 years in Syria, Lebanon, Turkey, Algeria and Pakistan revealed six lines, namely, ILC 72, 191, 194, 202, 3279 and Pch 15 to be resistant across locations and years. These lines appear to have location nonspecific resistance and will be useful in breeding program. The differential reaction of some lines in 9 out of 10 locations tested indicates the presence of different races. Results of CIABN-Desi indicated five lines to be resistant in Syria and Pakistan. Some lines found resistant to fusarium wilt and stunt at ICRISAT Center were found resistant also to blight. Four of the ascochyta blight resistant lines were also found resistant to botrytis grey mold under field conditions in Pakistan.

References

AHMAD, T., HASANAIN, S.Z. and SATTAR, A. 1949. Some popular methods of plant disease control in Pakistan. Agr. Pakistan 1:18–22.

ANONYMOUS.1931. Plant pathology – Rapport sur le functionnement de l'inst-des Recherches Agron. pendant l'annee 1930. 9:411–455.

ANONYMOUS. 1938. Plant diseases. Rep. Dep. Agr. Punjab, 1936–37. pp. 52–56.

ANONYMOUS.1949. Annual Administrative Report of the Development of Agriculture, United Provinces, for the year 1947–48. 88pp.

AUJLA, S.S. 1964. Study of eleven isolates of *Phyllosticta rabiei* (Pass.) Trot.; the causal agent of gram blight in the Punjab. Indian Phytopath. 17:83–87.

AUJLA, S.S. and BEDI,P.S. 1967. Relative reaction of different varieties of gram to blight disease incited by *Phyllosticta rabiei* (Pass.) Trot. in the Punjab. J. Res. Punjab agric. Univ. 4:214–216

AZIZ, M.A. 1962. C 727 – a new blight-resistant gram variety for Barani areas. W. Pakist. J. Agr. Res. 1:165–166.

BEDI, K.S. and ATHWAL, D.S. 1962. C 235 is the answer to blight. Indian Fmg. 12(9):20–22.

BEDI, P.S. and AUJLA, S.S. 1969. Variability in *Phyllosticta rabiei* (Pass.) Trot.; the incitant of blight disease of gram. J. Res. Punjab agric. Univ. 6:103–106.

BUSHKOVA, MME L.N. 1960. Susceptibility of chickpea varieties to Ascochytosis. Zashch. Rast; Mosk. 5:55.

ESER, D. 19 76. Heritability of some important plant characters, their relationship with plant yield and inheritance of Ascochyta blight resistance in chickpea (*Cicer arietinum* L.). Ankara Universitesi Ziraat Fakullesi Yayinlari. 620, 40 pp.

GANEVA, W; MATSOV. B. 1977. Comparative testing of introduced and local samples of chickpea. "Resteniev" din Nauke. 14(9):57–59.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to Ascochyta blight. Indian Phytopath. 27:643–645.

HAFIZ, A. 1952. Basis of resistance in gram to Mycosphaerella blight. Phytopathology 42:422–424.

HAQ, M.A., SHAKOOR, A., SIDIQ, M. and MAHMUD EL-HASSAN. 1981. Induction of *Ascochyta* blight resistant mutants in chickpea. Mutation Breeding Newsletter 17:5–6.

KAISER, W.J. 1972. Occurrence of three fungal diseases of chickpea in Iran. Plant Prot. Bull. FAO 20:74–78.

KAISER, W.J. 1973. Factors affecting growth, sporulation, pathogenicity, and survival of *Ascochyta rabiei*. Mycologia 65:444–457.

KHIL'KO, V.G. 1974. Study on the resistance of chickpea to Ascochytosis. Genetike; selektsii 53(3):132–136.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 938. The control of the blight disease of gram by resistant types. Curr. Sci. 7(2):45–47.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1943. Further studies on the control of gram blight. Indian Fmg. 4:413–416.

NENE, Y.L. 1981. A world list of pigeonpea (*Cajunus cajan* (L.) Millsp.) and chickpea (*Cicer arietinum* L.) pathogens. ICRISAT, pulse pathology progress report 3, pulse pathology, ICRISAT, P.O. Patancheru, Andhra Pradesh 502 324, India.

NENE, Y.L., HAWARE, M.P. and REDDY, M.V. 1979. International disease nurseries. International Workshop on Chickpea Improvement, ICRISAT, 28 Feb–2 Mar 1979, Patancheru, A.P., India.

PUERTA ROMERO, J. 1964. Gram blight: Isolation of the fungus *P. rabiei* and the study of gram varieties possibly resistant to it. Boln. Patol. Veg. Eng. Agr. 27:15–52.

RADKOV, P. 1970. Susceptibility of some chickpea varieties to *Mycosphaerella rabiei*. Rastit. Zasht. 18(9):22–27.

REDDY, MV. and NENE, Y.L. 1978. Screening of *Cicer* spp. for resistance to Ascochyta blight. Page 305 *in* Proc. of 3rd Int. Congress of Plant Path. Munich, 1978. (Abstr.).

SANDHU, T.S. 1972. New sources of resistance to gram blight disease. (*Ascochyta rabiei*). Madras agric. J. 59:41.

SINGH, G. 1978. Screening of genetic stock of gram against blight. Indian J. Mycol. Plant Path. 8(1):124.

SINGH, K.B., HAWTIN, G.C., NENE, Y.L. and REDDY, M.V. 1981. Resistance in chickpea to Ascochyta blight. Plant Dis. 65:586–587.

SOLEL, Z. and KOSTRINSKI, J. 1964. The control of Ascochyta anthracnose of chickpea. Phytopath. Mediterranean 3: 119–120.

VAN DER MAESEN, L.J.G. 1972. *Cicer*-L. A monograph of the genus with special reference to the chickpea (*Cicer arietinum*), its ecology and cultivation. H. Veenman & Zonen, N.V. Wageningen, 342 pp.

VEDYSHEVA, R.G. 1966. Evaluation of the resistance of *Cicer arietinum* to *Ascochyta rabiei*. Vest. se'.Khoz. Nauki, Mosk. 11(12):109–111.

VIR, S. and GREWAL, J.S. 1974. Physiologic specialisation in *Ascochyta rabiei*. The causal organism of gram blight. Indian Phytopath. 27:355–360.

Discussion

Y.L.Nene

I wish to draw attention to a slide shown by Dr. Singh in which he showed ICC -5127 to be resistant to the blight and grey mold. ICC -5127 is actually F8. Does it mean F8 is still resistant in Pakistan?

K.B.Singh

It seems that F8 still retains resistance to ascochyta blight at least in Pakistan. In addition, it was noted that it possesses tolerance to botrytis grey mold.

B.A.Malik

F8 was grown in Pakistan in early fifties, but later on it lost its resistance and was replaced by a variety 12/34. Since ICC 5127 is F8 and has shown resistance during 1980–81, it may indicate that the inoculum of the race which had knocked it down in early fifties has now vanished.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

International Program on Horizontal Resistance to Ascochyta Blight

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Although chickpea in Morocco has relatively few important diseases and pests, *Ascochyta rabiei* can cause 100% crop loss when conditions are favourable to the development of the disease. Late-sown chickpea can escape the disease but the drop in yield due to late sowing does not make this procedure very acceptable. To solve this problem, a breeding program has been started to develop agronomically acceptable cultivars with stable resistance to ascochyta blight. The main difference between the International Program on Horizontal Resistance (IPHR) and a conventional breeding program is the type of resistance used. The polygenic nature of the resistance and its quantitative expression require a specific approach. In this paper the horizontal resistance breeding program is discussed and its progress evaluated.

Horizontal – Vertical Resistance

The terms horizontal and vertical resistance originate from van der Planck (1968) who described two types of resistance which can be defined as follows:

Vertical Resistance	*Horizontal Resistance*
Gene for gene action	No gene for gene action
Qualitative	Quantitative
Monogenic	Polygenic
Affects onset of epidemic	Affects development of epidemic

In agricultural history, horizontal type resistance (HR) has generally remained more stable than vertical type resistance (VR). Although VR can be made more durable by proper management, in host-pathogen systems in which the pathogen is highly flexible, HR should be preferred. HR and VR have been described as two mutually excluding phenomena; in practice, however, the dif-

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ference between the two types is less pronounced. For example, VR can affect epidemic development while HR can show small gene for gene interactions.

It is assumed that HR and VR as described by van der Planck are two extreme expressions of resistance in the host plant, which means that between these two extremes all kinds of "mixed resistances" can exist. The stability of a given resistance in a host plant to a pathogen will depend on its components; many VR components will mean instability while a resistance possessing many HR components will be stable.

Pathology

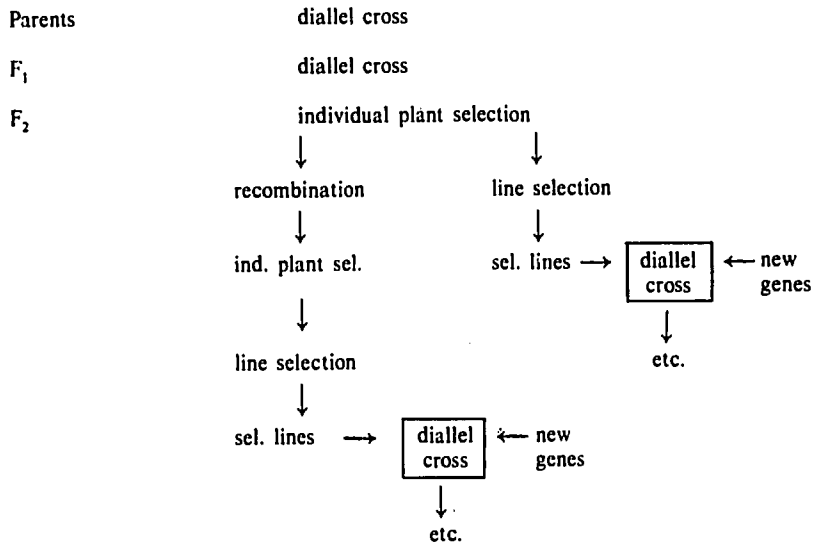
A very important part in an HR breeding program is the identification and characterization of different resistance components in the host plant. A multitude of tests at different growth stages of the host can make detection of different resistance components possible. In the IPHR on chickpea in Morocco, the following seven tests are carried out on each cultivar to evaluate its resistance to blight and to identify different resistance components.

1. *Seed infection test:* Seeds of chickpea cultivars are infected with *A. rabiei.* Percentage germination is scored.
2. *Seeding test:* Seedlings of chickpeas are inoculated with *A. rabiei* spores. Observations are made on the development of the disease and the severity of the attack at a given time.
3. *Germination test:.* The germination rate of *A. rabiei.* spores on detached chickpea leaves is scored.
4. *Hair density :* The number of glandular hairs/given leaf surface is noted.
5. *Disease incidence:* The number of plants in the field showing symptoms two weeks after artificial inoculation is scored.
6. *Number of infected pods:* Percentage pods with pycnidia is scored for each cultivar at the end of the season.
7. *ICARDA field score:* It has been used as reference and as a preliminary selection method.

All tests (except the ICARDA score) have been checked for normality. Significant correlations between tests were found.

Breeding

The various resistance components in chickpea to blight are scattered over different varieties. The aim of the breeding program is to accumulate as many components as possible into good yielding cultivars. For this purpose, the following scheme is used:



The scheme provides optimal recombination and new genes can be introduced without much difficulty.

Present Status of the IPHR on Chickpea in Morocco

Since 1979 several different chickpea populations have been field tested. In these populations only natural selection has occurred. These populations have been compared with their original parent populations to see whether any improvement in resistance to *A. rabiei.* had taken place (Tab. 1).

All populations show a significant increase in resistance compared with their subsequent parent populations. The ICARDA score used for this evaluation is not enough to discover whether transgressive segregation has occurred, resulting in individual plants with a resistance higher than that of their parents. Some selections have already been tested in seedling tests and their levels of resistance have been compared with the resistance levels of their original parents. Of 50 selections tested, 10 show resistance levels in the seedling test which is significantly higher ($P<0.01$) than their parents, indicating that transgressive segregation has occurred.

Plants selected in 1980 in the progeny populations will be subjected to the following tests: (a) their levels of resistance will be tested with the experiments mentioned above; (b) the nature of their resistance will be investigated by inoculating them with different isolates of *A. rabiei.* and (c), the number of resistance genes in each selection will be determined.

Table 1.
Comparison between some selected populations and their subsequent parent populations.

	ICARDA score					$\bar{X}$
	1	3	5	7	9	
Populations						
114x	7	7	11	2		2.2 b
cc31	11	6	17			2.1 b
15x	66	32	14	3		1.6 a
Parents						
114x			3	9	3	4.0 d
cc31	2		4		1	2.7 c
15x	1		5	3	6	3.8 cd

After these tests the resistance of each cultivar can be defined from its components and characteristics and its stability can be estimated.

Results until now indicate that the resistance selected possesses many HR traits (quantitative, polygenic, slowing down of epidemic), which permits some optimism as far as the stability of the resistance is concerned.

Reference

VAN DER PLANCK, J.E. 1968. Disease resistance in plants. Academic Press, N.Y. 206 pp.

Discussion

H.C.Weltzien

In your list of screening methods you have no method to screen for lower sporulation rates or decreased spore vitality. Is there any reason for this?

R.Pieters

The main reason has been the lack of time, but I think that these characteristics should be studied, because they are important factors in the development of an epiphytotic.

J.B.Smithson

What is the reason for including hair density among the tests for horizontal resistance?

R.Pieters

Malic acid is known to have an effect on the germination of *Ascochyta* spores. This acid is produced in the glandular hairs on the leaves. The correlation of hair density with resistance is probably caused by the increased concentration of malic acid on leaf surfaces with many hairs.

T.S.Sandhu

Are there any techniques available with which we can deal both with vertical and horizontal resistance at the same time in our breeding program, as vertical resistance masks the expression of horizontal resistance?

R.Pieters

I know of no method to assess the level of horizontal resistance in the presence of active vertical resistance.

M.V.Reddy

In order to identify the most relevant criteria, we are looking into the various disease reactions of the lines found resistant across locations which are supposed to have HR, and we hope to come up with a criterion or a set of criteria related with HR.

G.C.Hawtin

In the data you presented two of the parents were fairly highly resistant. How can you then separate vertical from horizontal resistance in the subsequent generations following crossing between these resistant lines?

R.Pieters

To avoid introduction of vertical resistance genes a variety will only be accepted as parent when it possesses following resistance characteristics: (i) quantitativity, (ii) no gene for gene action, and (iii) effect on the develoment of epidemic. Selections resulting from crosses between approved parents are checked for above mentioned characteristics again. On top of that, number of their resistance genes is estimated by crossing with an ultimate susceptible. The chance that vertical resistance will not be detected and eliminated in the described process seems to be small.

G.C.Hawtin

From your data and presentation I got the impression that you consider more than one locus to be involved in resistance. Can you comment further on this please?

R.Pieters

There is evidence that indeed more loci involving resistance exist. Specific crossing programs are carried out at the moment to identify these loci.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Strategy for Breeding Ascochyta Blight Resistant Cultivars

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Plant Breeder, ICRISAT: Plant Breeder, ICARDA:
Program Leader and Plant Breeder, ICARDA, respectively

Chickpea (*Cicer arietinum.* L.) is not known to occur in the wild, and the earliest report of this species was in 5450 BC (Helback 1959). Candolle (1882) considered its center of origin to be between Greece and the Himalayas and between Krim and Ethiopia. Vavilov (1926) indicated Hindustan and the Mediterranean as centers of origin, along with Ethiopia as a secondary center of diversity. van der Maesen (1972) believed that the species originated in the southern Caucasus and northern Persia, while Ladizinsky (1975) gave south-eastern Turkey as the center of origin.

Cubero (1975) identified two groups based on seed size, *macrocarpa* and *microcarpa*, and these correspond, respectively, to the terms 'kabuli' and 'desi' used by plant breeders, for the main groups of immediate interest for genetic improvement within the species. The kabuli chickpeas generally have larger seeds than the desi types and are characteristic of the Mediterranean area and are also adapted to spring sowing in Afghanistan, Iran and countries westward. The desi types are adapted to winter sowing in the Indian subcontinent, Ethiopia and Central America, though some cultivars are grown in spring in Afghanistan and Iran. The international work on this crop is also split geographically with the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria responsible for the kabuli types, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India responsible for the desi types.

Ascochyta blight (*Ascochyta rabiei* (Pass.) Lab.) is the most serious disease affecting chickpeas, and there are several reports of epidemic outbreaks in various parts of the world (Nene 1983). To avoid crop loss from ascochyta blight in West Asia and North Africa, chickpeas are sown in spring. There is large increase in productivity if the crop is winter-sown, but there is a danger of complete crop loss from blight in the absence of adequate control of this disease

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(Hawtin and Singh 1983). Ascochyta blight can also limit productivity in Pakistan, India, Ethiopia and Southern Europe. There are many ways of reducing the severity of the disease, such as rotation and the application of seed dressings and fungicides, but resistant cultivars would offer by far the most effective means of control.

The first resistant desi cultivar, namely, F8, was released 40 years ago in India (Luthra *et al.* 1941). This was followed by the release of C 12-34 in 1949 (Ahmed *et al.* 1949) and C 727 in 1962 (Aziz 1962) for Pakistan, and C 235 in 1962 (Bedi and Athwal 1962) for India. However, these cultivars soon became susceptible, owing to the occurrence of new races of ascochyta blight (Grewal and Vir 1974), and after 1962 there has been no report of release of a resistant desi cultivar. To the best knowledge of the authors, no resistant kabuli cultivar has ever been released for commercial production in West Asia and North Africa. As a result, only susceptible cultivars or landraces are being cultivated in an area in which ascochyta blight is endemic, resulting in instability of production.

Recently Kauser (1976) and Retig and Lehrer (1977) have reemphasized the need for the development of blight-resistant cultivars, and Haq *et al.* (1981) have advocated the use of mutation breeding. Several limitations such as the absence of stable sources of resistance and of effective screening techniques, combined with inability to identify physiologic races and ignorance of the genetic control of resistance, have in the past inhibited plant breeders from launching aggressive breeding programs. Singh *et al.* (1983) have reported several sources of resistance and an effective screening technique, and some information is available on the inheritance of resistance. The time thus seems ripe to attempt solving the blight disease problem through resistance breeding.

In this paper the progress made at ICARDA through the development of blight-resistant cultivars, and the future breeding strategies for developing genetic material for the endemic areas of the world are discussed.

Genetics of Resistance

Review of Past Work

In 1953, Hafiz and Ashraf reported that the resistance to ascochyta blight was determined by a single dominant gene in two parents, namely, F8 and FlO. Later Vir *et al.* (1975) and Eser (1976) reported a similar finding. Recently Singh and Reddy (1983) have reported that a single dominant gene conditioned resistance in four parents, ILC 72, ILC 183, ILC 200 and ICC 4935, whereas the resistance in ILC 191 was conferred by a single recessive gene. This was the first report on identification of a recessive gene governing resistance to blight. A summary of current information on inheritance of resistance is given in Tab. 1.

Now that a number of resistant sources have been identified at Tel Hadya and

Table 1
Inheritance of resistance to ascochyta blight in chickpea.

Source	Gene	Cultivars
Hafiz and Ashraf (1953)	Monogenic dominance	F_8, F_{10}
Vir et al. (1974)	Monogenic dominance	IP 13
Eser (1976)	Monogenic dominance	Code no 72-92
Singh and Reddy (1983)	(a) Monogenic dominance	ILC 72, ILC 183, ILC 200, ICC 4935
	(b) Monogenic recessive	ILC191

in other countries through the Chickpea International Ascochyta Blight Nursery (CIABN), it will be essential to study the genetics of resistance in greater detail. Such knowledge is important in planning an effective breeding strategy, especially in view of the probable existence of physiologic races of ascochyta blight.

Identification of Resistance Genes

Twenty lines identified to be resistant at Tel Hadya for more than 2 years are being crossed with four testers including three susceptible and one resistant cultivar (ICL 482). This study is expected to indicate the nature of the inheritance of resistance to blight and whether the dominant gene already identified in ILC. 482 is the same as that in other resistant lines having dominant alleles for resistance.

Pyramiding of Resistance Genes

A 10 x 10 diallel has been designed with the objective of identifying different resistance genes and incorporating them into a single genotype. This pyramiding of different resistance genes may provide a better opportunity to a plant breeder to develop cultivars with a longer life span, i.e. which are not overcome by a new pathotype. The lines comprise eight resistant and two susceptible genotypes which originated in different geographic regions. Pyramiding of the resistance genes will be achieved by crossing the F1s.

Suggestions for Future Study

A certain basic knowledge of the mechanism of disease resistance is vital for combating ascochyta blight satisfactorily, such as:

1. Biochemical basis of resistance.
2. The extent to which plants can tolerate a certain level of disease without deleterious effect on yield. Such knowledge will be helpful in shifting emphasis from the often unstable specific resistance to generalized resistance conferring an acceptable level of protection with a minimum loss in yield.

3. Identification of as many sources of resistance to different physiologic races as possible will assist in developing cultivars with a broad spectrum of resistance.

Implications of Information on Genetics of Resistance on Breeding Strategy

1. In the absence of detailed information on the nature of inheritance of resistance, both lines showing location-specific resistance should be used. This would provide diversity among the material being generated through hybridization and should result in increased protection against new virulent forms or races of the pathogen.
2. If different major genes are identified, the development of multiline cultivars may provide a good long-term solution.
3. The identification of resistance to blight which is conferred by polygenic systems would allow the development of cultivars with horizontal resistance which is again likely to be a better long-term solution than relying on a single major resistance gene.

Conventional Breeding Methods

Introduction and Selection

ICARDA has assembled 3400 kabuli germplasm accessions from 29 countries of the world. All have been evaluated for resistance to ascochyta blight at Tel Hadya and 22 lines have been found resistant. These lines were tested for adaptation and yield at Tel Hadya and other sites in Syria, and elsewhere in the Mediterranean region. As a result, ILC. 482 (ex-Turkey) seems to be a candidate for release for commercial cultivation in a few countries. This line has a high yield potential, wide adaptation, high level of resistance to ascochyta blight and acceptable seed characteristics. This is perhaps one of the rare examples of a line having resistance to a disease with a high yield potential, and wide adaptation being identified directly from a germplasm collection. Future collections of germplasm may yield additional sources of resistance.

Another line, ILC. 484 also has good agronomic and resistance attributes like ILC 482 and may also be considered for release in a few countries. Three tall lines, namely, ILC. 72, 202 and 3279 have been found resistant to ascochyta blight and high yielding but have unacceptable seed characteristics for the Mediterranean region. But in certain countries where mechanical harvesting is the primary requirement and such seed quality is acceptable, these lines may also become candidates for release.

Hybridization

Three methods of selection, namely, pedigree, bulk and backcross are available after hybridization in a self-pollinated crop like chickpea. Some of the genes for resistance to blight have been found in a background that can also contribute to improved adaptation and yield. This provides an opportunity of choosing either the pedigree or bulk method of handling segregating generations. The pedigree method has been widely used in breeding for disease resistance and the majority of disease-resistant cultivars have been produced by this method (Allard 1960). The bulk population method of breeding is largely adopted by plant breeders to advance the segregating populations with ease and to allow natural selection to play a role. Both the pedigree method of selection for development of cultivars with a high yield, resistance to blight and wide adaptation, and the bulk population method of selection for development of large-seeded types with high yield, blight resistance and less photoperiod-sensitivity have been adopted. The procedures and progress made are described.

Pedigree Method

Crosses are made between adapted and high-yielding cultivars and blight-resistant lines and the resulting hybrid populations are handled as shown schematically in Fig. 1. The F1 generation is grown in the off-season at Terbol (in the Beqa'a valley of Lebanon). The F2 generation is sown in the blight disease nursery at Tel Hadya (near Aleppo, in northern Syria) and resistant plants with desirable traits for simply inherited characters, such as maturity, height and seed characteristics are selected. F3 progeny rows are grown in the off-season at Terbol and single plants are selected from superior progenies. Again selection is made for normal maturity, which under the decreasing day length at the end of the season, may also be associated with reduced photoperiod-sensitivity. F4 progeny rows are grown back in the disease nursery at Tel Hadya and single plants are visually selected from superior yielding and resistant progenies. F5 progeny rows are again grown at Terbol where selection for maturity is practised and finally F6 progeny rows are grown in the disease nursery in an augmented design with three checks for the identification of superior yielding, disease-resistant and uniform progenies which are then bulked for replicated yield testing. Selection for maturity assumes importance because many of the sources of resistant genes are present in lines originating from the USSR and are usually late in maturity.

The material in hand and their disease resistance is shown in Tab. 2. It may be seen from this table that 375 lines resistant to ascochyta blight are available in the program which is now being further expanded.

Since the aim is to develop resistant cultivars suitable for winter, early spring and normal spring sowing, the material from the F5 generation onwards will be grown in all planting seasons to allow selection of material adapted to the various ecosystems.

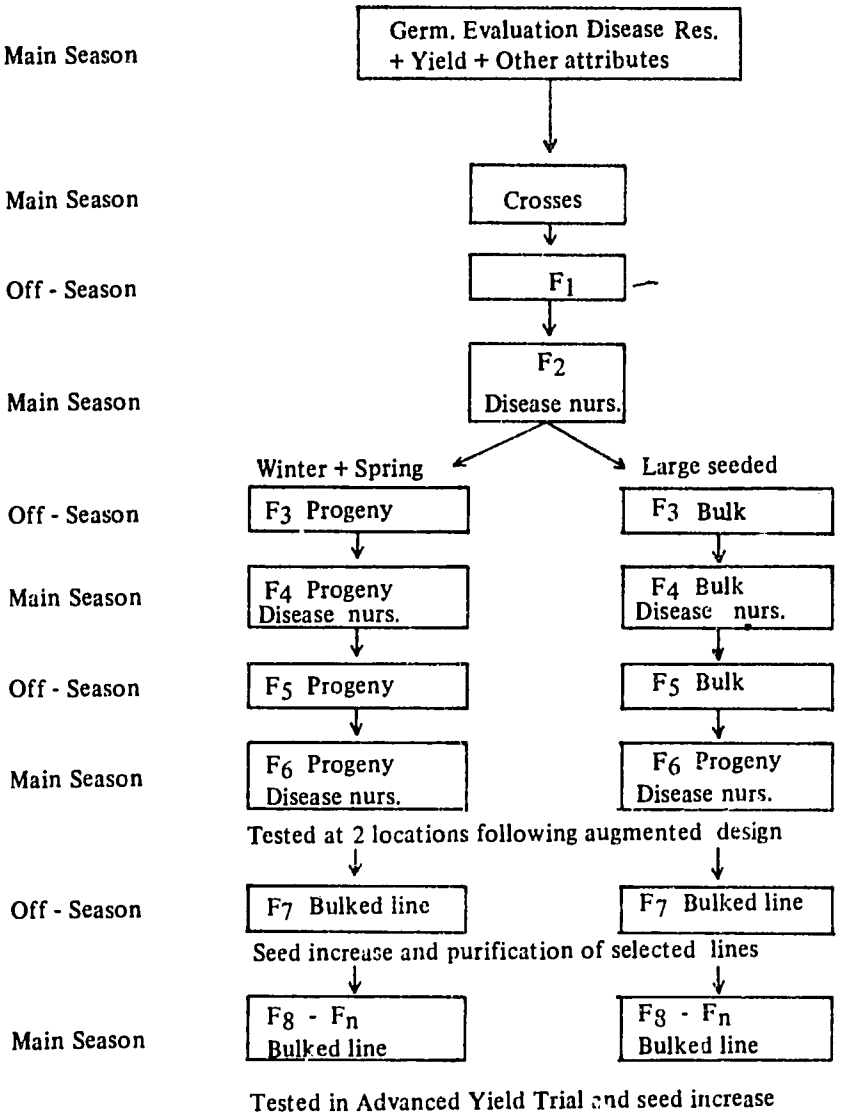

Figure 1
Development of segregating and blight-resistant cultivars at ICARDA.

Bulk-Population Breeding

The large seeded and less photoperiod-sensitive lines are crossed with high-yielding and resistant but photoperiod-sensitive lines (Fig. 1). The Fls are ad-

Table 2
Reactions to ascochyta blight for bulked lines and segregating generations sown during 1980–81 at Tel Hadya.

Bulked lines/ segregating generations	Reaction to ascochyta blight on 1–9 scale									Total
	1	2	3	4	5	6	7	8	9	
Bulked line	0	0	5	11	20	6	3	1	0	46
F_6 progeny	0	0	24	0	42	8	72	49	195	390
F_5 progeny	0	0	2	0	5	3	39	51	94	194
F_4 progeny	0	0	344	0	322	121	181	26	27	1021

vanced in the off-season site at Terbol. The F2 segregating populations are raised in the disease nursery at Tel Hadya, where mass selection is practiced for blight resistance. The resistant plants are bulk harvested and large seeds are selected in the laboratory, bulked and grown in the F3 generation in off-season at Terbol, where selection for less photoperiod-sensitive types is exercised because the day length is about 14 hours at the start of the growing season and it decreases as the season advances. These plants having longer day length requirements do not mature and are naturally eliminated. The mature plants are bulk harvested. It is envisaged that this practice will continue until F6 when single plants will be selected, yield tested and elite lines made available to cooperators for evaluation under their local conditions and for possible release as commercial cultivars.

Breeding for Stable Resistance

Breeding for Horizontal Resistance

van der Plank (1968) developed the concept of horizontal resistance which is a race-nonspecific or broad-based or field resistance, and follows the concept of the multiline as proposed by Borlaug (1959). According to the former author, when a variety is more resistant to some races of a pathogen than others, the resistance is called "vertical" or "perpendicular". When resistance is evenly spread against all races of the pathogen it is called "horizontal" or "lateral". He further explained that vertical resistance implies a differential interaction between varieties of the host and races of the pathogen; in horizontal resistance there is no differential interaction. He proposed that in breeding for horizontal resistance such as field resistance, vertical resistance can be prevented from interfering in two ways; first, by excluding vertical resistance genes, and second, by exposing genotypes under test to a race of the pathogen virulent enough to match any vertical resistance genes that may be present.

Robinson (1976) has further developed the concept of horizontal resistance stating that agriculturally horizontal resistance is permanent resistance. Its use does not lead to a "boom-and-bust cycle" of cultivar production, and breeding for horizontal resistance should be cumulative; a good cultivar being replaced by a better cultivar.Horizontal resistance provides an incomplete but permanent disease control. Polygenically inherited resistance is always horizontal but not all horizontal resistance is inherited polygenically. Horizontal resistance and horizontal parasitic ability are independent of each other and according to Robinson (1976) there is no need to search for a source of resistance. Even within the most susceptible cultivars it is possible to develop horizontal resistance utilising random cross-pollination in a genetically flexible population combined with selection pressure exerted by the parasite, which should occur as naturally as possible. This screening should lead to an increase in all variable resistance mechanisms against all locally important parasites; for this reason there should be a breeding program for each ecological zone. Some 10-15 host generations are necessary in a population of some thousands of individuals. Robinson (1976) has cited a successful example of breeding maize cultivar resistance to *Puccinia polysora* in East Africa; although it was accidental rather than arising out of a well planned experiment.

Nelson (1978), who never accepted the term horizontal resistance in the sense proposed by van der Plank (1968), stated that he did not believe that there were special vertical genes, but that there were just genes for resistance, some of which had major effects in some situations or genetic backgrounds, and the same genes in other situations or backgrounds could have less effect or contribute to partial or rate reducing form of resistance. He believes that many major plant diseases can be managed effectively by returning the plants and their parasites to genetic equilibrium. He suggested the development of cultivars with many vertical resistance genes (genetic pyramiding), so that even if the pathogen is able to develop the necessary virulence, the residual reaction of the resistance genes confers a high degree of partial resistance, so that a disease epiphytotic will not occur.

Although there is divergence of views on breeding for horizontal resistance, such a program has been initiated at ICARDA. Four crosses, involving susceptible parents with a rating of 7, were made in 1979-80 and the F1s were grown during the 1980 off-season. A large number of F2 plants were grown in the 1980-81 season in the disease nursery and their reactions to blight are given in Tab. 3.

A number of plants in the segregating populations were more resistant than either of the parents involved in the crosses. In future, a group of moderately resistant plants will be crossed with another group of similar plants selected within each cross. Also a group of moderately resistant plants in one segregating population will be crossed with a similar group of plants in another population.

The F1s will be advanced in the off-season and the F2 populations grown in the

Table 3
Disease rating in F_2 populations initiated for development of cultivars with horizontal resistance at Tel Hadya, 1980–81.

Cross/Parents		Total plants	No. of plants with rating of 1	2	3	4	5	6	7	8	9
ILC 1919	P_1	45	0	0	0	0	12	13	17	0	3
(ILC 1919 × ILC 2582)	F_2	812	0	0	0	3	69	220	367	69	84
ILC 2589	P_2	13	0	0	0	0	4	3	1	3	2
ILC 1919	P_1	44	0	0	0	0	2	11	19	6	6
(ILC 1919 × ILC 215)	F_2	304	0	0	0	1	14	59	108	84	38
ILC 215	P_2	51	0	0	0	0	3	12	29	5	2
ILC 249	P_1	42	0	0	0	0	9	16	15	1	1
(ILC 249 × ILC 1919)	F_2	633	0	0	12	24	189	203	168	20	17
ILC 1919	P_2	28	0	0	0	0	3	4	13	4	4
ILC 215	P_1	47	0	0	0	0	5	9	22	9	2
(ILC 215 × ILC 190)	F_2	496	0	0	11	8	42	116	165	88	66
ILC 190	P_2	45	0	0	0	0	7	12	21	0	5

main season in the disease nursery and the crosses indicated above will be repeated. This process will be repeated until a high level of resistance is achieved. At that stage individual plants will be selected and tested for uniformity, seed yield and other agronomic traits. These lines will then be made available to cooperators working in similar ecological zones for selection in local conditions and for use in breeding programs.

Multilines

In 1952, Jensen proposed that a multiline cultivar in oats might be produced through the blending of seed of several compatible pure lines. Later Borlaug and Gibler (1953) and Borlaug (1959) reported the use of a modified backcross technique in developing a wheat multiline incorporating a number of different resistance genes in a single genotype. 'Miramaer 63' was the first multiline wheat cultivar released for commercial cultivation in Columbia (Anon. 1963). Frey *et al.* (1977) have released 11 multiline oat cultivars for commercial cultivation in the Corn Belt of the USA. Tumult, a multiline wheat cultivar, was released in 1977 in the Netherlands (Groenewegen 1977). Recently CIMMYT and Indian programs have developed a number of multiline cultivars in wheat (Rajaram *et al.* 1979; Gill *et al.* 1979; Luthra and Rao 1979). Theoretically the life expectancy of a multiline should be longer than that of a pure line because it is very unlikely that a virulent race may appear which can overcome all the resistance components of a multiline cultivar. The disadvantages of the classical multiline are many. The major one is that there is no gain in yield over the recurrent parent

and by the time a multiline cultivar is developed there may be other heavier yielding pure lines available for release. The various alternatives to multiline, such as a mixture of species, cultivars, related lines and/or isogenic lines have been described by Groenewegen and Zadoks (1979).

In the absence of identification of physiologic races of ascochyta blight no progress can be made towards the development of multiline cultivars, but the development of mixture of cultivars may give some advantage. Accordingly, three mixtures of cultivars of chickpea lines resistant to ascochyta blight were synthesized. The cultivars used had shown differences in resistance across the region (Singh *et al.* 1983) but were similar in maturity, height and seed characteristics (Tab. 4). Equal quantity of seed of cultivars used was blended for each mixture. The composition of these mixtures was as follows:

MC1: ILC 482, 484 and 249
MC2: ILC. 72, 202 and 3279
MC3: ILC 191, 194 and 201

Table 4
Maturity, height, seed type and size of cultivars used in study of mixtures of cultivars.

ILC	Maturity	Height	Seed type	Seed size
482	Mid-late	Normal	Kabuli	Medium
484	Mid-late	Normal	Kabuli	Medium
249	Mid-late	Normal	Kabuli	Medium
72	Late	Tall	Intermediate	Small
202	Late	Tall	Intermediate	Small
3279	Late	Tall	Intermediate	Small
191	Late	Normal	Kabuli	Small
194	Late	Normal	Kabuli	Small
201	Late	Normal	Kabuli	Small

An advanced yield trial of nine cultivars and the three mixtures was sown at Tel Hadya and Lattakia in Syria during the 1980-81 season. The results of the evaluation for disease are shown in Tab. 5; the mixture showed a little advantage over the mean individual components. It is yet to be seen whether this reduced disease infections is reflected in grain yield after the trial is harvested.

Table 5
Average reaction of cultivars and mixture of cultivars (MC) to ascochyta blight in Advanced Yield Trial at Tel Hadya, 1980–81.

Entry	Blight reaction on 1–9 scale	
	Plant basis[1]	Plot basis[2]
ILC 482	4.07	3.00
ILC 484	4.03	3.50
ILC 249	7.11	7.00
Mean	5.07	4.50
MC1	5.38	5.00
ILC 72	3.76	3.25
ILC 202	4.65	4.75
ILC 3279	3.55	3.00
Mean	3.99	3.67
MC2	3.40	3.00
ILC 191	4.05	4.25
ILC 194	3.23	3.25
ILC 201	4.43	5.00
Mean	3.90	4.17
MC3	3.75	4.25

1. Average reaction of four replications on 20 randomly selected plants per replication.
2. Average reaction of four replications.

Development of Resistant Desi Cultivars - International Cooperation

The breeding program at ICARDA concentrates on the kabuli chickpeas cultivated in West Asia and North Africa, whereas ICRISAT deals with desi chickpeas cultivated in Pakistan and countries eastward. In 1978-79 and 1979-80 the crop in Pakistan was devastated by ascochyta blight, and in an attempt to overcome this serious problem, ICARDA and ICRISAT are developing a joint project.

ICRISAT will make crosses and produce F2 populations. Part of the F2 seed will be grown at Hissar (India) for single-plant selection. The following season a part of seed of each F3/F4 (if the F3 is advanced in the off-season) progeny will be grown and assessed at Tel Hadya for resistance to blight and the remaining seed will be grown at Hissar to assess yield and adaptation. Progenies found both blight resistant at Tel Hadya and high yielding at Hissar will be retained. This process will continue for at least two cycles. The resistant and superior yielding

lines will then be made available to cooperators in Pakistan, Iran and Ethiopia through the ICRISAT International Chickpea Cooperative Trial.

Another approach will be to screen the F2 populations for resistance at Tel Hadya, and furnish F3 resistant bulks to cooperators the following season for selection under local conditions.

Seed Production Strategy

Most of the countries in North Africa and West Asia, where there is a possibility of introducing winter chickpeas, do not have a seed industry for legumes. There is thus a need for national programs to start such an industry for the large-scale multiplication of seed, seed certification, and monitoring of purity, correct labelling, etc. There is also a need to develop criteria for the identification of resistant cultivars either through the use of marker genes, or such methods as protein or enzyme banding techniques. Unless these measures are undertaken there is a danger of a wrong cultivar being grown in winter and its possible devastation by ascochyta blight.

Blight infection in the field often starts from infected seed, and it is therefore essential to ensure supplies of disease-free seed. This can be ensured by multiplying seed during spring when the disease rarely occurs, by roguing the infected plants before harvest, and by treating the seed with Benlate and Calixin M mixture (Reddy 1980). The disadvantage of this scheme is reduced production of seed per unit area, but the overriding factor must be the production of disease-free seed.

Conclusions

Over the past few years the chickpea program at ICARDA has made good progress towards the development of screening techniques, the identification of sources of resistance to ascochyta blight and the incorporation of resistance into superior agronomic backgrounds. Some information on the inheritance of resistance has also been obtained.

Several of the germplasm lines with resistance are also high yielding and have good seed quality. These lines could be released and made available to farmers in the near future. Ascochyta blight resistance would not only result in improved yield stability for the normal spring-sown crop but would also enable substantial yield increases to be achieved if the crop were to be planted in the winter.

The future breeding program at ICARDA will continue to place a strong emphasis on ascochyta resistance and eventually most of the materials developed at the Center will have resistance incorporated.

Variation in disease reaction has been observed from location to location. Although a few lines have been identified as resistant across all sites so far tested, many more lines have reacted differentially. One reason for this may be the existence of different pathotypes and further information on variation in virulence of the pathogen is urgently required. It is necessary that all resistant lines developed at ICARDA should be widely tested in as many environments as possible. It is also important to reevaluate the germplasm collection in other environments as other sources of resistance may exist which may not have been identified by the screening conducted at Tel Hadya.

In order to ensure that this widespread testing is carried out effectively it is essential that ICARDA and the national programs work together in close collaboration. In several countries, adequate facilities and manpower already exist for carrying out the work. In others, ICARDA may be able to make a special input in terms of training, frequent visits, etc. In order to work more closely with the national programs, ICARDA is currently developing several subregional programs (e.g. for North Africa) through which it is hoped to achieve a greater degree of coordination of the research efforts. The joint efforts of all concerned scientists in the region are required if the advantages of ascochyta-resistant cultivars are to be realized on farmers' fields in the region.

References

AHMED, T.S., HASANAIN, N. and SATTAR, A. 1949. Some popular methods of plant disease control in Pakistan. Agric. Pakist. 1:18–22.

ALLARD, R.W. 1960. Principles of Plant Breeding. John Wiley & Sons, Inc., New York. 485 pp.

ANONYMOUS. 1963. Rockefeller Foundation. Program in Agric. Sci. Annu. Rep. 1962–63. 310 pp.

AZIZ, A.M. 1962. C 727 – a new blight-resistant gram variety for Barani areas. W. Pakist. J.Agric. Res. 1:165–166.

BEDI, K.S. and ATHWAL, D.S. 1962. C 235 is the answer to blight. Indian Fmg. 12(9):20–22.

BORLAUG, N.E. and GIBLER, J.W. 1953. The use of flexible composite wheat varieties to control the constantly changing stem rust pathogen. Page 81 *in* Abstsr. Annu. Meeting of Am. Soc. Agron.

BORLAUG, N.E. 1959. The use of multiline or composite varieties to control airborne epidemic diseases of self-pollinated crop plants. Pages 12–26 *in* Proc. 1st. Intern. Wheat Genet. Symp., Winnipeg, 1959.

BORLAUG, N.E. 1965. Wheat, rust, and people. Phytopathology 55:1088–1098.

CANDOLLE, A. de. 1882. L'origine des plantes cultivees. Paris.

CUBERO, J.I. 1975. The research on the chickpea (*Cicer arietinum*) in Spain. Pages 117–122 *in* International workshop on grain legumes, ICRISAT, Patancheru, A.P., India.

ESER, D. 1976. Heritability of some important plant characters, their relationship with plant yield and inheritance of Ascochyta blight resistance in chickpea (*Cicer arietinum* L.). Ankara University Ziraat Faklutesi Yayinlari 620. 40 pp.

FREY, K.J., BROWING, J.A. and SIMONS, M.D. 1977. Management systems of host genes to control disease loss. *In* Genetic Basis of Epidemics in Agriculture. Annals. New York. Sci. 287:255–274.

GILL, K.S., NANDA, G.S., SINGH, G. and AUJLA, S.S. 1979. Multilines in wheat: A Review. Indian J.Genet. 39(1):30–37.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to Ascochyta blight.Indian Phytopath. 27:643–645.

GROENEWEGEN, L.J.M. 1977. Multilines as a tool in breeding for reliable yields. Cereal Res. Commun. 5:125–132.

GROENEWEGEN, L.J.M. and ZADOKS, J.C. 1979. Exploiting within field diversity as a defence against cereal disease: A plea for polygenotype varieties. Indian J.Genet. 39 (1):81–94.

HAFIZ, A and ASHRAF, M. 1953. Studies on the inheritance of resistance to mycosphaerella blight in gram. Phytopathology 43:580–581.

HAQ, M A., SHAKOOR, A., SADIK, M. and EL-HASAN, M. 1981. Induction of Ascochyta blight resistant mutants in chickpea. Mutation Breeding Newsletter. Issue No. 17:5–6.

HAWTIN, G.C. and SINGH, K.B. 1983. Problems and potential of winter sowing of chickpea in the Mediterranean region. This volume, pp. 7-16.

HELBACK, G. 1959. Domestication of food plants in old world. Science 130-3372:365-372.

JENSON, N.F. 1952. International diversification in oat breeding. Agron. J. 44:30–34.

KAUSAR, A.C. 1976. Development of disease-resistant chickpea varieties. Pages 213–220 *in* Genetic Diversity in Plants. Proc. International Sym. held in 1976 at the Agricultural University, Faisalabad, Pakistan.

LADIZINSKY, G. 1975. A new *Cicer* from Turkey. Notes Roy. Bot. Gard. Edinb. 34:201–202.

LUTHRA, J.K. and RAO, M.V. 1979. Escape mechanism operating in multilines and its significance in relation to leaf rust epidemics. Indian J. Genet. 39 (1):38–49.

LUTHRA, J.S., SATTAR, A. and BEDI, K.S. 1941 Determination of resistance to blight disease, *Mycosphaerella rabiei* Kovaceveski= *Ascochyta rabiei* (Pass.) Lab. in gram types. Indian J.Agric. Sci. 11:249–264.

NELSON, R.R. 1978. Genetics of horizontal resistance to plant diseases. Ann. Rev. Phytopathol. 16:359–378.

NENE, Y.L. 1983. A review of Ascochyta blight of chickpea (*Cicer arietinum* L.) This volume, pp.17-33.

RAJARAM, S., SKOVMAND, B., DUBIN, H.J., TORRES, E., ANDERSON, R.G., ROELFE, A.P., SAMBROSKI, D.J. and WATSON, I.A. 1979. Diversity of rust resistance of the CIMMYT multiline composite, its yield potential and utilization. Indian J.Genet. 39(1):60–71.

REDDY, M.V. 1980. Calixin M-An effective fungicide for eradication of *Ascochyta rabiei* in chickpea seed. International Chickpea Newsletter No. 3:12.

RETING, B. and LEHRER, W.L. 1977. Breeding chickpeas (*Cicer arietinum*) for resistance to *Ascochyta rabiei* blight. Phytoparasitica 51:61–62.

ROBINSON, R.A. 1976. Plant Pathosystems. Springer-Verlag, Berlin. 184 pp.

SINGH, K.B., NENE, Y.L., and REDDY , M.V. 1983. International screening of chickpea for resistance to Ascochyta blight. This volume, pp. 65-85.

SINGH, K.B. and REDDY, M.V. 1983 Inheritance of resistance to Asocochyta blight in chickpea. Crop Sci. (Accepted)

VAN DER MAESEN, L.J.G. 1972. *Cicer*.L. — A monograph of the genus with special reference to the chickpea (*Cicer arietinum* L.), its ecology and cultivation. H.Veenman 2 Zonen, N.V. 72–10, Wageningen. 342 pp.

VAN DER PLANK, J.E. 1968. Disease Resistance in Plants. Academic Press, N.Y. 206 pp.

VAVILOV, N.I. 1926. Studies on the origin of cultivated plants. Inst. Appl. Bot. Plant Breed., Leningrad.

VIR, S., GREWAL, J.S. and GUPTA, V.P. 1975. Inheritance of resistance to Ascochyta blight in chickpea. Euphytica 24:209–211.

Discussion

B.A. Malik

Dr. K.B.Singh mentioned that desi crosses will be made at ICRISAT and F_2 generation will be supplied to ICARDA for screening against *Ascochyta rabiei* and developing material for inclusion in the international nurseries. My suggestion is that F_2 bulk (depending upon the availability of seed) may be supplied to the cooperating national programs for selection under their own conditions. This would accelerate the process of cultivaral evolution and would reduce the risk of disease incidence due to diversified testing.

J.B. Smithson

F_2 populations of crosses involving *Ascochyta*-resistant desi lines will certainly be provided to Pakistan next season.

H.C. Weltzien

Were your mixtures or multilines exposed to natural infection or to artifical inoculation? The principle of multiline effect can only work when a natural epiphytotic is observed and the slower disease progress is measured.

K.B. Singh.

The trial was grown at Tel Hadya and Lattakia Under Tel Hadya conditions the disease pressure was high as the experimental plot was entirely surrounded by susceptible genotypes, whereas at Lattakia, the experiment has been grown away from disease nursery. But the disease development and spread was high at both the locations.

T.S. Sandhu

For launching a breeding program for pyramiding genes in a simple cultivar or development of multilines we need information that genes in the resistant sources are located at different loci and are not multiple alleles of the same gene. I am afraid this information is lacking in chickpea in respect of resistance to ascochyta blight.

K.B. Singh

Our knowledge about the genetics of resistance to blight is limited. This is precisely the reason that we propose to identify the genes first and then to incorporate them in a single genotype. The information about the races of the pathogen and sources of resistance for each race is essential before initiating any program for the development of multilines in chickpeas.

F.A. Elsayed

The resistance of mixtures, which you have discussed in your presentation, are not even close to the definition of multilines?

K.B. Singh

We have not initiated any program for the development of mulitlines because we do not have information on races of blight pathogen. Only after establishing races and identifying sources of resistance to different races, one could initiate

the program for the development of multilines. We are exploring at the moment wheteher a mixture of cultivars would provide any gain in yield and/or resisitance to blight.

M.S. El-Matt

Infection by ascochyta blight affects growth and develoment of plants adversely. What is their effect on yield and how were losses assessed?

K.B. Singh

Ascochyta blight, in epiphytotic conditions, can cause total yield loss. The yield loss is estimated by growing a set of genotypes under diseased and disease-free conditions. In diseased plots the epiphytotic conditons are artificially created, whereas in the disease-free plots, the crop is protected through fungicide. The yield loss is estimated by subtracting the yield obtained in diseased plot from that obtained in diesease-free plot.

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Role of Fungicides in the Management of Ascochyta Blight of Chickpea

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Traditionally the use of fungicides in agriculture has been popular with crops which give high economic returns. Their use in rainfed agriculture with low and unreliable yields has been very much limited. In crops such as chickpea, at the present yield levels, the best way of controlling the diseases is through cultivars with durable resistance. In developing countries where sufficient food buffers have not yet been built up, stability of yield becomes all the more essential because the consequences of "boom-and-bust" cycles of production associated with cultivars with vertical resistance genes can be more disastrous. Development of cultivars with durable resistance and with all other desirable characters is a time consuming process, or even may not be possible in the near future. Therefore, integrated use ofcultivars with vertical resistance and fungicides may help in both increasing and stabilizing production. This paper discusses the possible role of fungicides in the management of ascochyta blight of chickpea as seed dressings, foliar protectants in combination with resistant genotypes, or as stop-gap arrangements whenever the resistance loses its effectivity, and as short-term alternatives to resistant cultivars.

Seed Dressings

In crops such as chickpea, at the present yield levels, fungicides can only be feasible and economical when used as seed dressings. The highly seed-borne nature of *Ascochyta rabiei* in chickpea makes fungicidal seed-treatments essential and useful (Gobeleg 1956; Halfon-Meiri 1970; Khachatryan 1961; Lukashevich 1958; Luthra and Bedi 1932; Maden *et al.* 1975; Sattar 1933; Zachos 1952). Treatment of seeds with effective fungicides can greatly help in reducing the initial inoculum level and preventing the spread of the disease or races into areas

where they are not present. Seed treatment, especially of resistant cultivars may be much more effective both by preventing the entry of new races and reducing the pathogen population and thus selection pressure. Therefore, the resistant types that show pod infection may particularly need seed dressing.

Since the time chickpea seed infection was first detected, attempts have been made to eradicate the pathogen by several treatments (Ibragimov *et al.* 1966; Kaiser *et al.* 1973; Khachatryan 1961; Luckashevich 1958; Sattar 1933; Zachos 1951; Zachos *et al.* 1963). Recently, Reddy (1980) found treatment with calixin M (11% tridemorph + 36% maneb) alone or in combination with benlate to completely eradicate the fungus from naturally infected seed with deep lesions. The fungicide treatment did not affect the germination and there was no noticeable phytotoxicity. Preliminary studies indicated that seed treatment could also give protection to the seedlings against the external source of inoculum for up to 2 months. Screening of newer systemic fungicides should be undertaken.

Foliar Protectants with Resistant Genotypes

It is expected that with the good sources of resistance available at present, chickpea cultivars with resistance to blight will soon be developed. However, development of cultivars with durable resistance may take time, so cultivars with vertical resistance have to be released for cultivation. Due to the existence of physiologic races in the blight pathogen, the effectiveness of such resistance is likely to be lost in time (Hanounik 1980; Singh *et al.* 1981; Singh, Nene and Reddy 1983; Vir and Grewal 1974a). The continuous monetary support for scientific teams to cope with new races by developing new cultivars puts a considerable financial strain on governments. Development of new races from time to time also limits the efforts of plant breeders to make headway with yields. The combined use of resistant genotypes and effective fungicides may help in lengthening the life of the cultivars with vertical resistance (Hanounik 1980).

None of the resistant lines identified so far is free from infection even though they have a very high level of resistance (Singh *et al.* 1981; Singh, Nene and Reddy 1983). It is not uncommon in these lines to observe some lesions on stems causing girdling and with heavy sporulation. Preliminary studies on inoculation of the lines with isolates from such lesions indicated a higher disease severity. The application of the fungicide Bravo on resistant genotype ILC 3279 was found to reduce both disease severity and suppress the development of lesions with heavy sporulation indicating that combined effects of resistance and fungicide may prolong the effectivity of resistance (Hanounik 1980).

Further work on these lines with newer systemic fungicides, different genotype combinations under different environmental conditions with different races may prove more fruitful.

Stop-Gap Foliar Protection

When a cultivar loses its effectiveness in resistance, despite all efforts to maintain the gains of resistance breeding, the best alternative to control the disease until new sources of resistance are identified is to use fungicides as foliar protectants. Other disease management practices such as change in the cropping pattern to meet such situations may not be popular with farmers because of other problems.

Short-Term Alternative to Resistant Cultivars

Several good sources of resistance in both desi and kabuli background have been identified and efforts are under way to develop resistant and high-yielding cultivars. However, development of resistant cultivars with all desirable characters for different geographic regions is a time consuming process. In countries where the losses due to blight are heavy and no resistant cultivars are available, fungicides as foliar protectants have to be used until resistant cultivars are developed. The greater demand for this legume and the remunerative prices should make the use of fungicides feasible.

In the past, considerable work on the use of fungicides as foliar sprays to control blight has been done. Some of the fungicides that were found to be effective recently were Zineb, Ferbam, Maneb, Captan and Daconil (Hanounik 1980; Puerta Romero 1964; Retig and Tobolsky 1967; Se, Nycirek *et al.* 1977; Solel and Kostrinski 1964; Vir and Grewal 1974b). Under highly favorable conditions for disease development, none of these fungicides, even with as many as 12 applications, was found to give sufficient protection across the seasons at ICARDA. There is a great need to search for more efficient systemic fungicides which may be more economical to use. This is all the more essential as the development of resistant cultivars for certain specific locations or races of the pathogen may take a very long time, or may even not be possible in the near future.

Summary

The most ideal way of controlling ascochyta blight of chickpea is through the use of cultivars with durable resistance. In the absence of such resistance, fungicides, in addition to as seed dressers, when applied with genotypes having vertical resistance may help in lengthening their life and thus stabilize production. Fungicides that could completely eradicate the blight pathogen from the infected chickpea seed are available. Under experimental conditions, quite a few fungi-

cides have been found to be effective as foliar protectants. But search for additional and more effective fungicides for foliar protection should continue. Such fungicides are essential during the periods when resistance breaks down, or for areas where resistance sources are not available.

References

GOBELEG, M. 1956. Research work on the varieties and areas of spread of bacterial and parasitic diseases affecting and contaminating the seeds of cultivated plants grown in certain provinces of central Anatolia as well as the approximate degree of damage caused by such diseases. Zir. Fak. Yaginl, 107, 62, 131 pp.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to Ascochyta blight. Indian Phytopath. 27:643-645.

HALFON-MEIRI, A. 1970. Infection of chckpea seeds by *Ascochyta rabiei* in Israel. Plant Dis. Reptr. 54:443-445.

HANOUNIK, S.B. 1980. Influnece of host-genotype and chemical treatment on severity of Ascochyta blight in Chickpea. International Chickpea Newsletter 2:13.

IBRAGIMOV, G.R., AKHMEDOV, S.A. and GARADAGI, S.M. 1966. Use of phenthiuram and phenthiuram molybdate against diseases of fodder beans and *Cicer arietinum* under Azerbaidzhani conditions. Khimiya sel'. Khoz. 4:23-24.

KAISER, W.J., OKHOVAT, M. and MOSSAHEBI, G.H. 1973. Effect of seed-treatment fungicides on control of *Ascochyta rabiei* in chcikpea seed infected with pathogen. Plant Dis. Reptr. 57:742-746.

KHACHATRYAN, M.S. 1961. Seed transmission of *Ascochyta* infection in chickpea and the effectiveness of treatment (in Russian). Sbor. nauch. Trud. Nauch. issled. Inst. Zemledel. Armyan, S.S.R. 2:147-155.

LUKASHEVICH, A.I. 1958. Peculiarities of the parasitism of the causal agent of ascochytosis of chickpea, and their role in the accumulation of infection (in Russian). Rep. Acad. Sci. Ukr. 7:788-792. (Rev. Appl. Mycol. 39:647, 1960).

LUTHRA, J.C. and BEDI, K.S. 1932. Some preliminary studies on gram blight with reference to its cause and mode of perennation. Indian J. agric. Sci. 2:499-515.

MADEN, S., SINGH, D., MATHUR, S.B. and NEERGAARD, P. 1975. Detection and location of seed-borne inoculum of *Ascochyta rabiei* and its transmission in chickpea (*Cicer arietinum*). Seed Sci. & Tech. 3:667-681.

PUERTA ROMERO, J. 1964. Gram blight: isolation of the fungus *P. rabiei* and the study of gram varieties possibly resistant to it (in Spanish). Boln. Patol. Veg. Ent. Agr. 27:15-52.

REDDY, M.V. 1980. An effective fungicide for eradication of *Ascochyta rabiei* in chickpea seed. International Chickpea Newsletter 3:12.

RETIG, B. and TOBOLSKY, J. 1967. A trial for the control of Ascochyta in chickpeas. First Isreal Congr. Pl. Path.:50-51.

SATTAR, A. 1933. On the occurrence, perpetuation and control of gram (*Cicer arietinum* L.) blight caused by *Ascochyta rabiei* (Pass.) Labrousse, with special reference to Indian conditions. Ann. Appl. Biol. 20:612-632.

SE, NYCIREK, M., OLC, UN, and ZAVARAK, Y. 1977. Preliminary studies on chemical control of chickpea anthracnose (*Mycosphaerella rabiei* Kovacevski) in the Black Sea region. Zirai Mucadale Aras, tirma yilbigi, No. 11, 71-72.

SINGH, K.B., HAWTIN, G.C., NENE, Y.L. and REDDY, M.V. 1981. Resistance in chickpeas to *Ascochyta rabiei* (Pass.) Lab. Plant Dis. 65:586-587.

SINGH, K.B., NENE, Y.L. and REDDY, M.V. 1983. International screening of chickpea for resistance to Ascochyta blight. This volume, pp. 65–85.
SOLEL, Z. and KOSTRINSKI, J. 1964. The control of *Ascochyta* anthracnose of chickpea. Phytopath. Mediterranean 3:119-120.
VIR, S. and GREWAL, J.S. 1974 a. Physiologic specialization in *Ascochyta rabiei* the causal organism of gram blight. Indian Phytopath. 27:355-360.
VIR, S. and GREWAL, J.S. 1974b. Evaluation of fungicides for the control of gram blight. Indian Phytopath. 27:641-643.
ZACHOS, D.G. 1951. Studies on the disinfection of chickpea seeds (*Cicer arietinum* L.) infected with *Ascochyta rabiei* (Pass.) Labr. (in French). Ann. Inst. Phytopath. Benaki, 5, 2:76-87.
ZACHOS, D.G. 1952. A case of parasitism of chickpea (*Cicer arietinum* L.) seeds by *Stemphyllium botryosm* Wallr. (in French). Ann. Inst. Phytopath. Benaki, 6, 2:60-61.
ZACHOS, D.G., PANAGOPULOS, C.G. and MAKRIS, S.A. 1963. Researches on the biology, epidemiology and the control of anthracnose of chickpea (in French). Annls. Inst. Phytopath. Benaki, N.S., 5(2):167-192.

DISCUSSION

B. Baya'a

What source of inoculum did you use in your study? Did inocula consist of isolates from different geographical areas in Syria? Will results be the same if you utilize plant debris as an inoculum source?

S. Hanounik

They may not be the same, because *Ascochyta rabiei* has saprophytic activities and also has been shown to have its sexual phase. These stages in the life cycle on debris may introduce differences in the pathogenicity. It is always better to use natural inoculum.

S. Sithanantham

Under dry systems of cultivation, do you visualize foliar sprays with fungicides as a feasible practice? Many farmers in India prefer to apply insecticides as dusts rather than as sprays because of the practical difficulties in obtaining water to apply them.

S. Hanounik

Dusting of fungicides can be adopted one or two times during the season in areas where water is not available.

H.E. Gridley

Artificial reinoculation has produced more severe infection on a particular cultivar. Has this been observed naturally in the field?

S. Hanounik

Artificial inoculation with an isolate taken from severe-type lesions (type 4 lesions) produced more severe infection when artificially applied to the same resistant genotype. This has been observed in the field very rarely. The presence of type 4 lesions which are initiated or induced by a natural propagate

indicates that this propagate is more virulent. We still need to use inoculum from naturally infected tissue (without growing on agar) to know more about this questions.

M.V. Reddy

None of the varieties identified as resistant so far is free from infection. Stem lesions with heavy sporulation causing breakdown is not uncommon. It causes concern if we believe chickpea lines are genetically homogenous. It is important to know the reasons for it.

Y.L. Nene

I am interested in your study wherein you showed that isolation from a larger lesion produced on a resistant line pod developed severe infection on the pods of the same resistant line. Did you standardize the procedure of inoculation? Is it possible you used too much inoculum?

S. Hanounik

I used the same level of inoculum, as I did in my artificial inoculation procedure. But it is true that (i) our standard artificial procedure introduces new factors (nutrients etc.), that may influence virulence and (ii) when I used the pathogen from that specific lesion, in this case all my inoculum was from that virulent type, while our artificial inoculum contained isolates from different geographical regions.

F.A. Elsayed

The current discussion that reinfection of the same line from special lesions grown in that line could lead to more or larger lesions than what was originally, emphasizes the need to identify races and the setting up of differential genotypes is of greater importance than ever.

S. Hanounik

This is very correct.

Y.L. Nene

I think Dr. Hanounik has raised very interesting points particularly in relation to the existence of pathogenic variants in fungus population in the same field.

S. Hanounik

I think this is true because at our Lattakia disease screening site we receive seeds from different geographical areas and also our artificial inoculum consisted of isolates from different areas.

J.S. Grewal

How can variation develop in the fungus in the absence of perfect stage of the fungus?

S. Hanounik

Even in the absence of perfect stage the fungus can develop variation by muitation, adaptation or other methods at its disposal.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Control of Ascochyta Blight of Chickpea Through Clean Seed

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One of the most important diseases affecting chickpea (*Cicer arietinum*) in many countries is ascochyta blight caused by *Ascochyta rabiei*. It can inflict serious damage to the chickpea crop when cool, wet weather occurs during part of the growing season, particularly at flowering and fruiting (Kaiser 1973a; Luthra *et al.* 1935; Sattar 1933). Infected chickpea seed and trash are important in the epidemiology of the disease (Kaiser 1972; Luthra and Bedi 1932; Luthra *et al.* 1935; Sattar 1933; Zachos *et al.* 1963). One approach to control of ascochyta blight would be to produce pathogen-free seed for planting purposes. This paper reviews the information available on infection, survival, and transmission of *A. rabiei* in seed and relates this information to the production of *Ascochyta*-free seed.

Spread of the Pathogen in Infected Seed

Ascochyta blight of chickpea is widely distributed in the Middle East, North Africa and Southeast Asia (Commonwealth Mycological Institute 1979; Punithalingam and Holiday 1972). It has also been recorded from Canada, Australia and Tanzania (Biggs 1944; Cother 1977a,b; Morrall and McKenzie 1974). The incidence of *A. rabiei.* in naturally infected seed from countries where the disease is endemic may be higher than realized.

Maden *et al.*(1975) demonstrated that *A. rabiei* was present in 1-16+% of the seed in samples collected from six provinces in Central Anatolia, Turkey. Infected seed was responsible for the introduction of the pathogen into new areas, as occurred in 1973, when ascochyta blight of chickpea was reported for the first time in North America (Morrall and McKenzie 1974). A similar introduction on seed appears to have occurred in southwestern Iran in 1968 (Kaiser 1972) and Australia in 1973 (Cother 1977a,b).

Great care must be exercised in the movement of chickpea seed for research and commercial purposes from ascochyta blight infested areas to prevent the inadvertent introduction of the pathogen into new areas, or more virulent isolates or strains of *A. rabiei* into already infested regions.

Survival in Infected Seed

Ascochyta rabiei survives adverse environmental conditions for extended periods on internally or externally infected chickpea seeds, which may give rise to infected plants under favorable blight conditions. In Iran, the fungus survived 117 weeks in naturally infected chickpea seeds in a weather station shelter where temperatures rose to 45+°C during the summer (Kaiser 1972; Kaiser 1973a). The pathogen was still viable in over 50% of infected seed stored for 5 years at 2-5°C (W.J. Kaiser, unpublished data).

On the Indian subcontient, *A. rabiei* survived over 2 years on infested chickpea debris left in the field after harvest (Luthra *et al* 1935). However, the pathogen lost its viability rapidly when the infested refuse was buried (Kaiser 1973a; Luthra *et al.* 1935). *Ascochyta* spores survived on the surface of chickpea seeds after 5 months at 25-35°C (Sattar 1933), while one-third of those washed from heavily infected seeds germinated after 14 months at about 3°C (Maden *et al.* 1975). In nature, infected seed is thought to be the primary source of infection in many countries, e.g., Canada (Morall and McKenzie 1974), Greece (Zachos *et al.* 1963), India (Sattar 1933), Iran (Kaiser 1972; Kaiser 1973a) and Israel (Halfon-Meiri 1970). However, in some countries, infested trash may play an important role in local spread of the pathogen (Luthra *et al.* 1935; Zachos *et al.* 1963).

Site of Infection in Seed

Research by Halfon-Meiri (1970), Luthra and Bedi (1932) and Maden *et al.* (1975) has provided valuable information on the localization of the pathogen in chickpea seed.

Infection of seed may occur during cool, wet weather while immature or mature seeds are still in the pod, or during the harvesting and thrashing operations. Halfon-Meiri (1970) observed that 50-80% of the seed from chickpea pods with *Ascochyta* lesions were infected with *A. rabiei*, but that the pathogen could not be detected in seeds from apparently healthy pods collected from diseased plants.

Infected seeds may not show signs of fungal infection (Halfon-Meiri 1970; Luthra and Bedi 1932; Luthra *et al.* 1935; Maden *et al.* 1975). On seeds of white-

seeded chickpea lines, lesions were light dark brown (Halfon-Meiri 1970; Maden *et al.* 1975) and ranged in size from 1-4 mm in diameter (Halfon-Meiri 1970; Sattar 1933). Black pycnidia containing mature spores of the fungus were observed in many lesions, some of which formed concentric zones (Halfon-Meiri 1970; Luthra and Bedi 1932; Maden *et al.* 1975; Sattar 1933). In seeds with lesions, the fungus frequently penetrated the seed coat and could be isolated from cotyledonary tissues (Halfon-Meiri 1970; Luthra and Bedi 1932; Maden *et al.* 1975). The pathogen was detected also in embryos (Maden *et al.* 1975).

Controlling Ascochyta Blight Through Clean Seed

The production and use of *Ascochyta*-free seed is essential to prevent introduction of the pathogen into disease-free areas where environmental conditions may favor spread and development of blight. It may be necessary to use a combination of practices, like crop rotation, field sanitation and chemical seed treatments to produce blight-free seed. These measures should also be effective in controlling other pathogens that are seed-borne in chickpea (Cother 1977a; Cother 1977b; Kaiser 1972; Singh and Chohan 1976; Suhag 1973).

The following five factors are critical to the production of chickpea seed free from *A. rabiei*:

Arid Environment

Ascochyta blight of chickpea is dependent on cool, wet weather for its greatest spread and development (Kaiser 1973a; Luthra *et al.* 1935; Sattar 1933; Zachos *et al.* 1963). Surface-contaminated or internally infected seed is the most important method of spreading and perpetuating the disease (Kaiser 1973a; Luthra *et al.* 1935; Maden *et al.* 1975; Sattar 1933). Dry, warm weather impedes disease development and spread. It is preferable to locate seed production fields in arid areas where little or no rainfall occurs during the flowering and fruiting periods, or at harvest. If plants are watered during the growing season, this should be done by furrow irrigation, rather than overhead sprinkling.

Several seed-borne diseases of different food crops in the United States are controlled by producing seed in arid western areas (Snyder *et al.* 1965). For example, most of the bush snap bean (*Phaseolus vulgaris*) seed used for planting in the United States is produced in an arid region of southern Idaho (Zaumeyer and Meiners 1975).

Crop Rotation

It is highly desirable to grow chickpeas in rotation with other crops such as cereals, to prevent the buildup of *A. rabiei* on any infested trash that may be left in the field after harvest. Only chickpeas are susceptible to ascochyta blight in

nature. *Ascochyta* propagules on chickpea refuse will begin to lose viability as the debris begins to decompose. Certain practices, such as plowing, will speed up the decomposition of chickpea refuse. Crop rotation may also be effective in reducing the inoculum of other seed- or soil-borne chickpea pathogens.

Field Sanitation

It has been reported that *A. rabiei* is able to multiply on the chickpea refuse that is left in the field after harvest (Lukashevich 1958; Luthra *et al.* 1935; Zachos *et al.* 1963) thereby providing a potential source of fungal inoculum which may initiate new centers of infection from rain-splashed conidia. Therefore, any chickpea refuse that remains in the field after harvest should be destroyed by burning or burying. Deep plowing will hasten the decomposition of infested straw and remove it as a source of fungal inoculum.

Chemical Seed Treatment

Chickpea seeds introduced into an ascochyta blight free area should be treated with an effective fungicide as a precaution against inadvertently introducing the pathogen on infected seed. This is particularly important where the origin of the seed is uncertain. Treatment of chickpea seed with some of the newer systemic fungicides offers great promise in controlling surface and deep-seated infection by *A. rabiei.*

The incidence of ascochyta blight in chickpea seedlings in Iran was reduced by more than 80% and emergence increased by over 45% when inoculated seeds were treated with benomyl (Benlate) or thiabendazole (Mertect) (Kaiser 1973b). Reddy (1980) reported the eradication of *A. rabiei* in naturally infected chickpea seeds with the systemic fungicide tridemorph (Calixin M) used singly or in combination with benomyl.

Field Inspection

Ascochyta blight can be present in chickpea plantings in low levels which makes detection of the pathogen difficult. It is, therefore, essential that seed fields be inspected carefully at periodic intervals up to the time of harvest by qualified, trained personnel.

These inspections will also be useful in identifying the presence and potential importance of other seed-, soil- and vector-borne diseases. Field inspections should be coordinated with laboratory tests designed to detect *A. rabiei* and other seed-borne pathogens on chickpea seeds.

Conclusions

If the above practices are followed, it should be possible to prevent the introduction of ascochyta blight into disease-free areas or significantly reduce or eradi-

cate the disease from infested areas. The success of the clean seed program will be greatly strengthened if seed is produced under arid conditions.

References

BIGGS, C.E.G. 1944. Annual report, Department of Agriculture, Tanganyika Territory, 1943, 8 p. (Rev. Appl. Mycol. 24:8, 1945).

COMMONWEALTH MYCOLOGICAL INSTITUTE 1979. Distribution maps of plant diseases. Map 151. *Ascochyta rabiei* (Pass.) Labrousse on chickpea (*Cicer arietinum*).

COTHER, E.J. 1977a. Isolation of important pathogenic fungi from seeds of *Cicer arietinum*. Seed Sci. & Technol. 5:593-597.

COTHER, E.J. 1977b. Identification and control of root-rot fungi in *Cicer asrietinum* (chickpea). Plant Dis. Reptr. 61:736-740.

HALFON-MEIRI, A. 1970. Infection of chickpea seeds by *Ascochyta rabiei* in Israel. Plant Dis. Reptr. 54:442-445.

KAISER, W.J. 1972. Occurrence of three fungal diseases of chickpea (*Cicer arietinum*) in Iran. FAO Plant Prot. Bull. 20(4):73-78, 98.

KAISER, W.J. 1973a. Factors affecting growth, sporulation, pathogenicity, and survival of *Ascochyta rabiei*. Mycologia 65:444-457.

KAISER, W.J. 1973b. Effect of seed-teatment fungicides on control of *Ascochyta rabiei* in chickpea seed infected with the pathogen. Plant Dis. Reptr. 57:742-746.

LUKASHEVICH, A.I. 1958. (Peculiarities of the parasitism of the causal agent of ascochytosis of chickpea, and their role in the accumulation of infection. Rep. Acad. Sci. Ukr. 7:778-789.) (Rev. Appl. Mycol. 39:647, 1960).

LUTHRA, J.C. and BEDI, K.S. 1932. Some preliminary studies on gram blight with reference to its cause and mode of perennation. Indian J. agric. Sci. 2:499-515.

LUTHRA, J.C., SATTAR,A. and BEDI, K.S. 1935. Life history of gram blight (*Ascochyta rabiei* (Pass.) Lab. = *Phyllosticta rabiei* (Pass.) Trot. on gram (*Cicer arietinum* L.)) and its control in the Punjab. Agric. & Livestock, India 5:489-498.

MADEN, S., SINGH, D., MATHUR, S.B. and NEERGAARD, P. 1975. Detection and location of seed-borne inoculum of *Ascochyta rabiei* and its transmission in chickpea (*Cicer arietinum*). Seed Sci. Technol. 3:667-681.

MORRALL, R.A.A. and McKENZIE, D.L. 1974. A note on the inadvertent introduction to North America of *Ascochyta rabiei*, a destructive pathogen of chickpea. Plant Dis. Reptr. 58:342-345.

PUNITHALINGAM, E. and HOLIDAY, P. 1972. *Ascochyta rabiei*. Commonwealth Mycological Institute, Descrip. Path. Fungi & Bact. No. 337. 2pp.

REDDY, M.V. 1980. Calixin M – an effective fungicide for eradication of *Ascochyta rabiei* in chickpea seed. International Chickpea Newsletter 3:12.

SATTAR, A. 1933. On the occurrence, perpetuation and control of gram (*Cicer arietinum* L.) blight caused by *Ascochyta rabiei* (Pass.) Labrousse, with special reference to Indian conditions. Ann. Appl. Biol. 20:612-632.

SINGH, I. and CHOHAN, J.S. 1976. Fungi associated with seeds of gram (*Cicer arietinum*) and control of pathogenic ones. Indian J. Mycol. Plant Pathol. 6(1):71-72.

SNYDER, W.C., GROGAN, R.G., BARDIN R. and SCHROTH, M.N. 1965. Overhead irrigation encourages wet weather plant diseases. California Agric. 19(5):11.

SUHAG, L.S. 1973. Mycoflora of gram (*Cicer arietinum*) seeds: Pathology and control. Indian J. Mycol. Plant Path. 3:40-43.

ZACHOS, D.G., PANAGOPOULOS, C.G. and MAKRIS, S.A. 1963. Recherches sur la biologie, l'épidemiologie et la luttre contre l'anthracnose du pos-chiche. Ann. Inst. Phytopathol. Benaki, n.s. 5:167-192.

ZAUMEYER, W.J. and MEINERS, J.P. 1975. Disease resistance in beans. Annu. Rev. Phytopathol. 13:313-334.

Discussion

In the absence of Dr. Kaiser, Dr. Nene presented the paper.

G.C. Hawtin

It is mentioned in Dr. Kaiser's paper that ascochyta blight was introduced with the seed into Australia. This country has very starict quarantine laws – are such regulations of any use?

Y.L. Nene

I suppose mistakes can occur. I am unable to offer any additional information.

M.V. Reddy

The development of resistant cultivars can also be helpful in producing clean seed. Even though the seed movement may not prevent the entry of disease into new areas forever, it can considerably delay the movement of new races.

J.B. Smithson

Are ULV formulations of the fungicides available?

S. Hanounik

No ULV formulation of Bravo is available. Most ULV sprays are used with insecticides. Some work , however, is being done in Syria.

G.C.Hawtin

It is not only water for spraying which is a problem in the use of fungicides. Perhaps of greater importance is the fact that when sprays are needed in the winter, the soil may be too wet to allow access for spraying, particularly with tractor mounted equipment.

Y.L. Nene

While foliar sprays may have limited use, seed dressing with an appropriate fungicide should be effective.

J.S. Grewal

The present conventional spray fungicides cannot be used by farmers because of the cost, time, and number of sprays required to control the disease. I agree with Dr. Nene that seed treatment with systemic fungicide which can provide protection to the seedling for some time can be a real answer to the problem.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Third Session: Winter Sowing

Agronomic Studies on Winter Chickpeas

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The productivity of an agro-type can be maximized by developing the agronomic practices and crop genotypes that would ensure matching of various phases of crop growth and development with the periods of crop season when most of the physical factors of environment are at their optimum for these phases. The winter planting of chickpeas, in the 'lowland' zone of West Asia and North Africa, which is characterized by coastal to continental Mediterranean climate, is one such exercise in optimizing the matching of growth phases with the environment.

The climatic endowments of the 'lowland' zone of the West Asia and North Africa region have been discussed in detail by Harris (1979), Kassam (1981) and Smith and Harris (1981). From these studies, it is clear that in most of this zone, a favorable soil moisture balance (because of increasing rainfall and low evaporative demand, coupled with mild temperatures) permits the winter period to be quite suitable for extending the potential growing season of a crop like chickpea, which is traditionally planted in spring.

The general trends in the physical environment in relation to various stages of ontogenic development of a chickpea crop, when planted on different dates, are shown in Fig. 1. It is apparent that the period of vegetative and reproductive growth of the winter-planted crop is exposed to relatively lower thermal and better moisture regimes than that of the spring-planted crop. Thus, the winter planting obviously results in the development of plants with a larger vegetative frame capable of supporting a bigger reproductive structure, thus leading to increased productivity. Data have been generated, in the past, to support this. They will be briefly discussed in later sections.

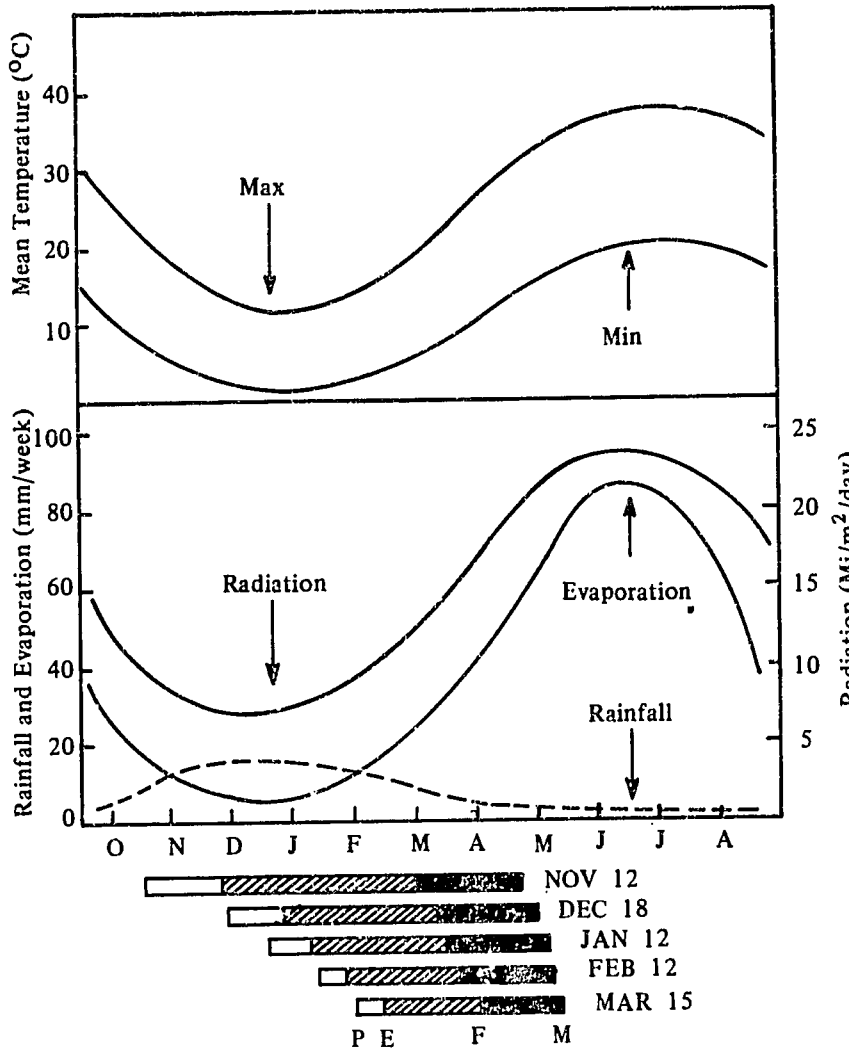

Figure 1

Phenological development of chickpeas at Tel Hadya, under different sowing dates, in relation to the long-term average climatological conditions. P, planting; E, emergence; F, flowering; M, maturity.

Owing to the differences in the physical environment, the winter-planted crop develops at a rate and produces the total phytomass and the economic yield which are substantially different from those of a spring-planted crop. It is logical, therefore, to expect that the agronomic requirements of the former might be

different from those of the latter. This paper presents the results of field experiments on the response of winter-planted chickpeas to a set of agronomic factors.

Response to Advancing the Date of Planting

For precise evaluation of the effect of advancing the date of planting from traditional spring planting, well designed replicated studies were started at the ICARDA site in Tel Hadya, northern Syria in the 1977-78 cropping season (Saxena 1980). Since the ascochyta blight resistant cultivars were not identified by then, studies had to be carried out with the agronomically superior genotypes and the well adapted local landrace (ILC. 1929) under fungicidal protection. In one such study, eight genotypes were planted on different dates covering a range from early winter to spring. The seedling establishment in the last date of planting (March 26) was extremely poor because of loss of moisture from the surface layer and also because of the damage by birds.

The effect of the first four dates of planting on the average performance of eight genotypes is shown in Tab. 1. Winter-planted crop resulted in taller plants with a slightly greater number of branches and a significantly higher number of pods than the spring-sown crop. This resulted ultimately in a yield advantage of 162% in the December-planted crop and of 112% in the early February planted crop over the one planted in the first week of March. Evaluation of various yield components revealed that the number of pods per plant was the most important single factor through which these yield increases were obtained.

The effect of advancing the date of sowing by various periods, in contrast to spring planting, on the performance of 20 diverse but promising genotypes was examined again during the 1978-79 cropping season when the date of planting

Table 1
Effect of dates of planting on the mean plant height, number of branches and number of pods per plant and grain yield of eight genotypes of chickpeas at Tel Hadya, 1977–78.

Date of planting	Plant height (cm)	Number/plant		Grain yield (kg/ha)
		Branches	Pods	
Dec 4	34.0	6.5	22.0	1767
Dec 29	32.3	6.5	19.4	1724
Feb 2	26.7	5.6	13.9	1415
Mar 6	22.3	5.0	10.9	666
LSD (5%)	3.9	0.8	3.0	211

ranged from November 22, 1978 to March 15, 1979 and the intervals were more evenly distributed over this period. To ensure good germination in the first date, an irrigation was given immediately after planting. Except for this, the whole experiment was raised under rainfed condition. The total seasonal rainfall was only 246 mm. As an average of 20 genotypes, the November-planted crop yielded more than 3000 kg/ha, and there was almost a linear decrease in yield as the planting date was delayed by various intervals up to March 15 (Fig. 2). The increase in the mean yield was 69, 128, 193 and 277% when the planting was advanced from March 15 to February 15, January 11, December 17 and November 22, respectively. Thus advancing the date of planting even to late or mid-winter proved substantially better than the early spring and late spring plantings. This observation is interesting from the point of view of the need for flexibility in the cropping system of the rainfed agriculture in dry areas.

As in 1977-78, the studies in 1978-79 were also conducted under fungicidal control as the seeds of *Ascochyta*-resistant cultivars were not available at that stage for large-scale trials. However, during 1979-80 season, several promising genotypes with an acceptable degree of tolerance to ascochyta blight became available. Hence, their response to the spread in the planting date from early winter to spring, was evaluated under rainfed condition (total seasonal precipitation 427 mm), along with several others making a total of 20 genotypes. Some of these genotypes were susceptible to ascochyta blight and were thus affected by the disease in the winter planting, in spite of the fungicidal spray, because of a heavy buildup of inoculum and favorable weather conditions for the spread of the disease. The individual yield data of some selected genotypes including four tolerant and one susceptible (ILC 1929) lines, as also the mean yield of all the 20 genotypes, are presented in Tab. 2.

The yield of ILC 482 cultivar increased by 69, 145 and 249%, respectively, under February 13, December 19 and November 20 planting dates over the yield under March 11 planting. Averaged over all the genotypes,the planting in winter (November 20) resulted in a 118% higher yield than from the spring planting (March 11). These results reemphasize the point that substantial gains in yield can be obtained by advancing the date of planting and that this advantage is particularly higher in the genotypes which have resistance to ascochyta blight in addition to good agronomic characters.

A more detailed analysis of the performance of an ascochyta blight tolerant cultivar, ILC 482, in relation to the date of planting is provided in Tab. 3. The yield of straw, which is economically important in the farming systems of the region, is also increased substantially by winter planting over spring planting, following a trend parallel to that of grain yield with no major change in the harvest index. The water-use efficiency of the crop, as computed by relating the grain yield to the total seasonal precipitation (427 mm), increases in winter planting following obviously the trend similar to the grain yield.

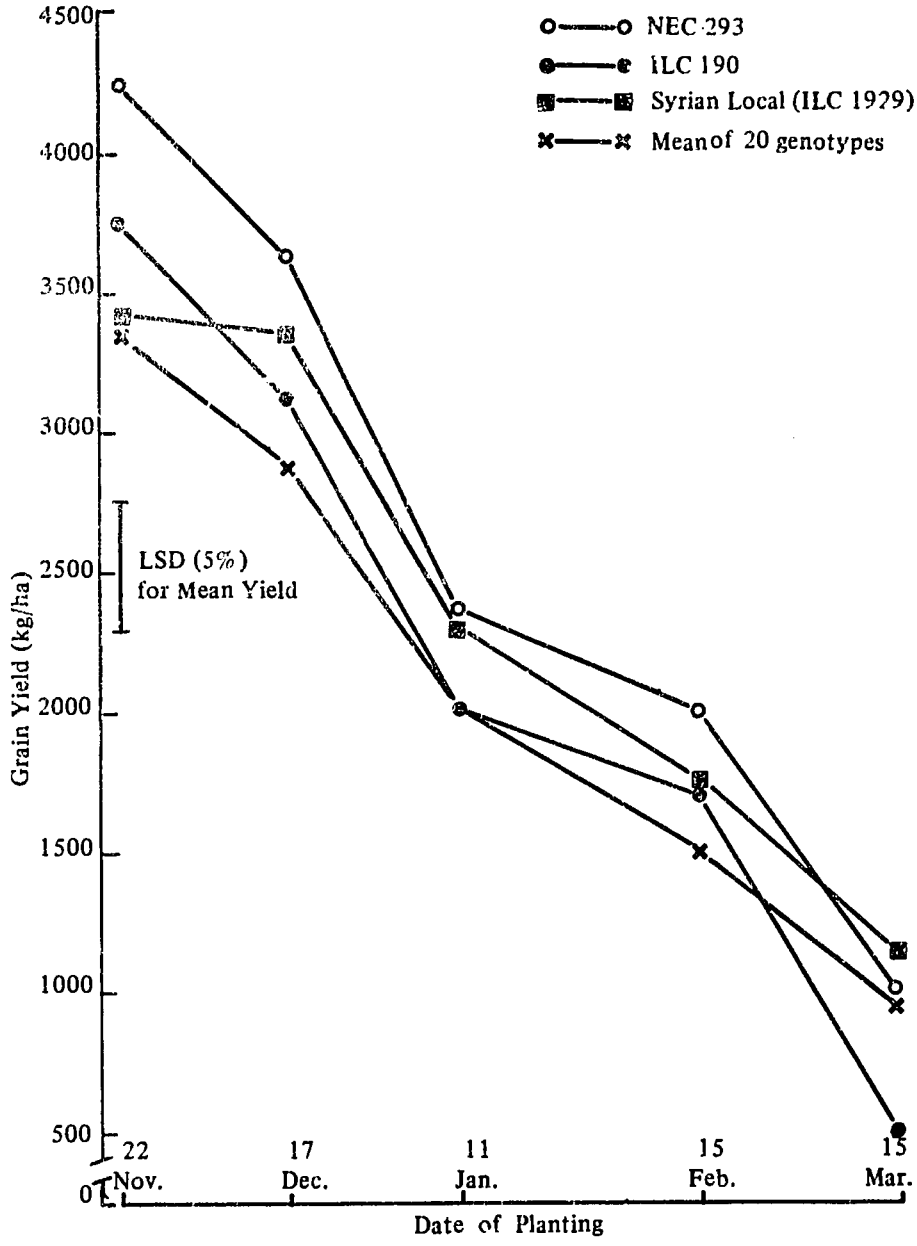

Figure 2
Grain yield of chickpea genotypes as affected by dates of planting in 1978–79 season at Tel Hadya.

Table 2
Grain yield of chickpea genotypes
as affected by dates of planting at Tel Hadya, 1979-80.

Genotypes	Grain yield (kg/ha)			
	Date of planting			
	Nov 20	Dec 19	Feb 13	Mar 11
ILC 482	3400	2470	1640	970
ILC 190	3310	2850	1540	920
ILC 202	2560	1930	1080	1090
ILC 215	2500	2160	970	260
Syrian Local (ILC 1929)	1000	1010	880	930
Mean of 20 genotypes	2100	1580	1130	970

LSD (5%) for dates 0.25 t/ha.
LSD (5%) for two genotypes at same date 980 kg/ha.

Table 3
Performance of ILC 482 in relation to the thermal regimes during vegetative(i.e. from emergence to onset of flowering) and reproductive (i.e. from onset of flowering to maturity) phases on different dates of planting at Tel Hadya, 1979-80.

Parameter	Dates of planting			
	Nov 20	Dec 16	Feb 13	Mar 11
1. Mean Temperature (°C) during:				
Vegetative phase:				
Maximum	14.0	17.8	21.3	23.3
Minimum	4.7	7.2	9.1	9.6
Average	9.4	12.5	15.2	16.5
Reproductive phase:				
Maximum	29.1	31.7	33.4	34.7
Minimum	12.6	14.9	15.7	17.8
Average	20.9	22.9	24.7	26.3
2. Yield (kg/ha)				
Shoot phytomass	6730	4960	3530	1920
Straw	3330	2490	1890	950
Grain	3400	2470	1640	970
3. Harvest index	0.50	0.49	0.46	0.50
4. Water-use efficiency (kg grain/mm. water/ha)	7.94	5.78	3.83	2.27

The major factors responsible for the improved performance of the winter crop include the prevalence of a more favorable thermal regime during its vegatative and, more importantly, reproductive phases (Tab. 3). Lower temperatures accompanied by the shorter day length protract the vegetative phase of the winter-planted crop and permit the plants to develop a vegetative frame which ensures not only a better interception of the photosynthetically active radiation (Tab. 4) early in the season but also provides more nodes which could become reproductive as soon as the inductive photoperiods become available. This also curtails the competition between the vegetative and reproductive growth, a feature which is common in spring-planted crop. The number of filled pods per unit area, therefore, increases (Tab. 1) in the winter-planted crop enabling it to give higher yields than the spring-planted crop. The significance of the relative duration of pre- and postflowering growth in affecting the morphology and economic yield in chickpeas has also been emphasized by Roberts *et al.* (1980).

The development of a good vegetative frame early in the season and the completion of major buildup of the economic yield during the period more favorable from the stand point of thermal and moisture regimes should make a winter-planted crop more stable in yield than the conventional spring-planted crop which develops in an environment of increasing moisture and thermal stress. Also, since a considerable proportion of the total phytomass of a winter-planted crop is produced during the period when the evaporative demand of the atmosphere is relatively low, such a crop can be extended to nonconventional areas experiencing relatively lesser rainfall than the traditional chickpea-growing areas. Thus, the winter planting of chickpeas can provide yet another cropping alternative to the farmers of dry areas.

Table 4

Plant growth of winter (Nov 30, 1980) and spring (Feb 22, 1981) planted ILC 482 chickpea at Tel Hadya, evaluated on Apr 9, 1981 when the winter crop started flowering. Photosynthetically active radiation (PAR) interception by the same on May 19, 1981 when winter crop was at advanced podding stage and spring crop at early podding.

Character	Winter crop	Spring crop
Dry weight per plant		
Leaves (g)	1.561 ± 0.212	0.210 ± 0.038
Stem (g)	1.307 ± 0.184	0.135 ± 0.018
Roots (g)	0.586 ± 0.118	0.075 ± 0.011
Nodule (mg)	69.7 ± 2.62	56.6 ± 1.91
Leaf area/plant (cm^2)	454.5 ± 73.4	73.0 ± 14.7
Root volume/plant (cm^2)	7.45 ± 1.06	1.75 ± 0.15
PAR interception (%)	77.9 ± 3.55	58.4 ± 3.38

Response to Plant Population

The winter-planted crop tends to respond better to increased plant population than the spring-planted crop under rainfed conditions. This became evident from the study in 1977-78 which was carried out using the local Syrian landrace (ILC 1929) at Tel Hadya (Fig. 3). Yields were higher with a population level of about 28 plants/m2 than with 18.5 plants/m2 in winter planting (December 4), whereas in the spring planting no such difference between the two population levels was observed. Observations on farmers' fields reveal that the plant population is seldom more than 20 plants per m2. Perhaps the increased inter-plant competi-

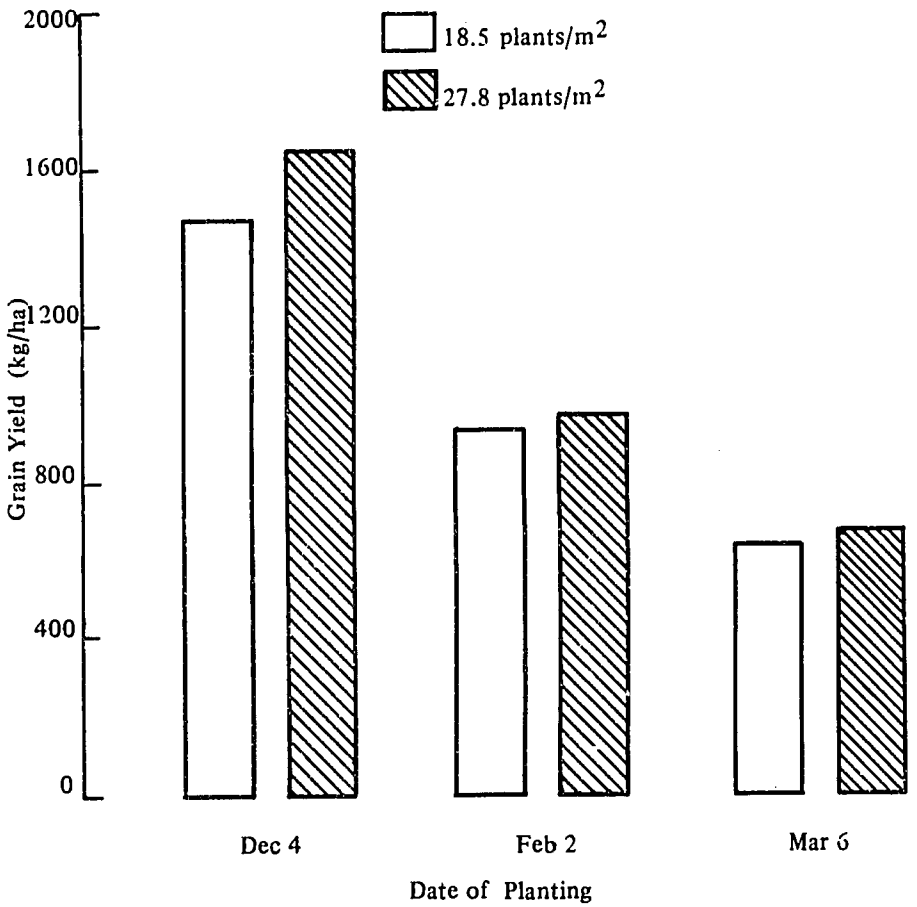

Figure 3
Effect of date of planting and plant population on the grain yield of chickpea at Tel Hadya during 1977–78.

tion for moisture in the spring-planted crop prevents the realization of yield advantage with increased plant population as is obtained in the winter-planted crop.

In order to identify optimum level of plant population for different rainfall situation, a plant population study was carried out with winter-planted crop of

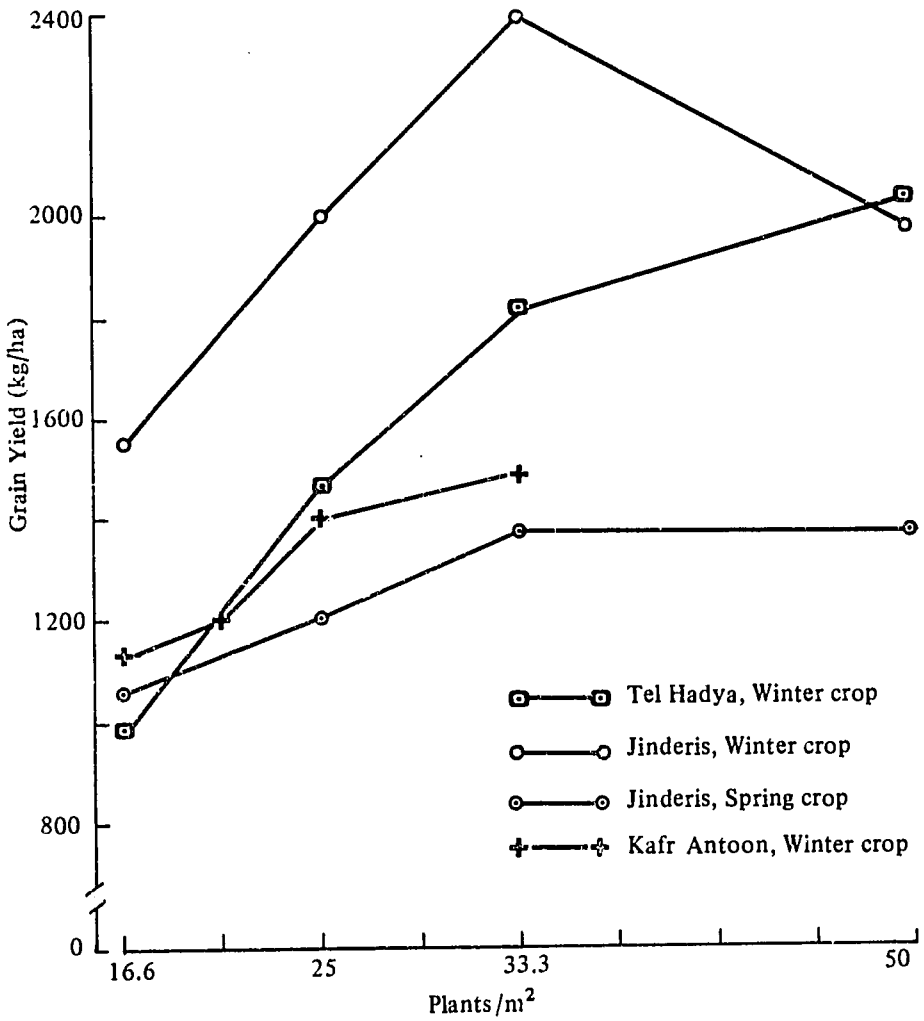

Figure 4
Effect of plant population on the seed yield of chickpeas at Tel Hadya (seasonal rainfall 427.8 mm; potential seasonal evaporation 620 mm), Jinderis (seasonal rainfall around 400 mm, potential evaporation 536 mm), and Kafr Antoon (seasonal rainfall 303 mm, Eo = 640 mm), during 1979–80 cropping season.

ILC 1929 at Tel Hadya and ILC 482 at Kafrantoon and Jinderis subsites of ICARDA during the 1979-80 cropping season. At Jinderis, which represents typical chickpea- growing area in northern Syria, a spring planting variable was also introduced in the study. The total seasonal rainfall and potential evapotranspiration at these three locations as well as the grain yield response to various levels of plant population are given in Fig. 4. It is evident that the yield of winter-planted chickpea increased conspicuously at all locations when plant population was raised from 16.6 plants/m2 to up to 33.3 plants/m2. Increasing the population beyond this level resulted in significant reduction in the yield at Jinderis, whereas at Tel Hadya the yield showed an increasing trend up to 50 plants/m2. Even the spring crop at Jinderis responded positively to increased population up to 33.3 plants/m2; the magnitude of increase was, however, not as high as in the case of winter-planted crop. From these data, it is evident that a population level of about 33.3 plants/m2 appears to be optimum for a situation having a seasonal precipitation around 400 mm.

In order to test the interaction between plant population response and moisture supply in greater detail, these studies are being carried out again at four ICARDA subsites during the 1980-81 cropping season. The data collected on the percent interception of the photosynthetically active radiation (PAR) by the canopy of ILC 482 chickpea at Tel Hadya at the advanced podding stage as affected by plant population and planting season are shown in Fig. 5. The seasonal precipitation has been around 350 mm. Under this condition, the increase in plant population from 16.6 to 50 plants/m2 has shown almost a linear increase in PAR interception in winter- planted crop as against an asymptotic trend beyond 25 plants/m2 in case of spring- planted crop. The latter might be attributed to increased inter-plant competition for limited available moisture supply at levels higher than 25 plants/m2. The differences in the interception of PAR by the winter- and spring-planted crop should reflect in the overall phytomass and economic yield.

Response to Nutrient Application

Since the yield levels of a winter-planted crop are much higher than those of the spring- planted crop, it is logical to expect that the mineral nutrient requirement of the former would also be considerably higher than that of the latter. Whereas on a soil of high native fertility this additional requirement of the nutrient may easily be met, on the soils with poor fertility status the limitation of the mineral nutrients might prove a significant constraint to the realization of the yield potential of a winter- planted crop.

An important dimension to the mineral nutrition of the crop is the fact that the crop is capable of meeting a major part of its nitrogen requirement by symbiotic

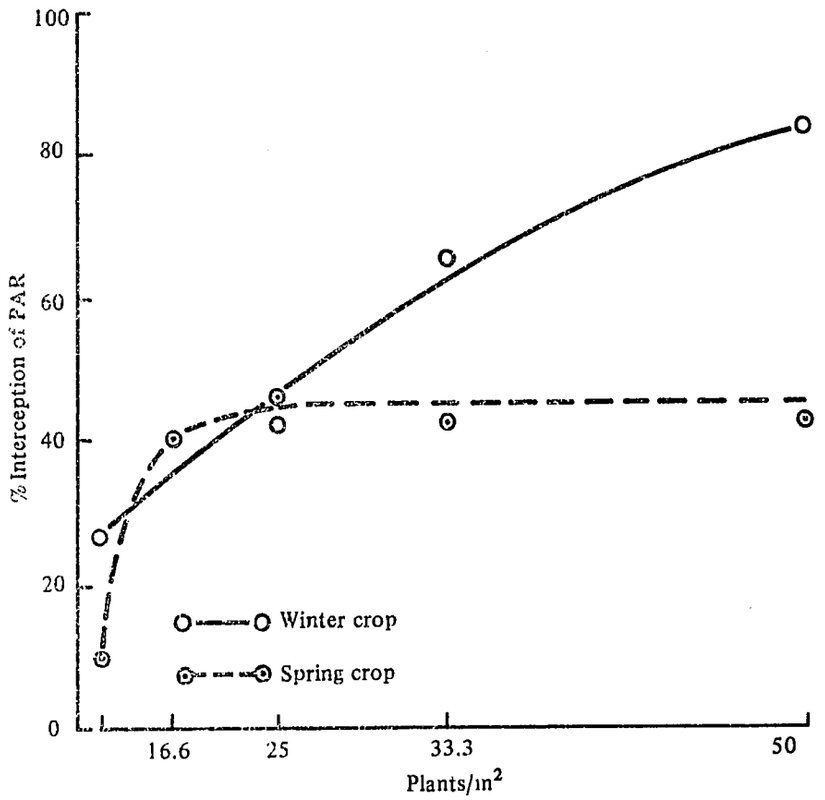

Figure 5
Effect of planting date and plant population on the percent interception of PAR by the canopy of ILC 482 planted in winter (Nov 19, 1980) and spring (Mar 4, 1981) at Tel Hadya. PAR measured at advanced podding stage.

dinitrogen fixation, provided the suitable *Cicer Rhizobium* is present in the medium and no other mineral nutrient is limiting the functioning of the symbiotic association. In view of the fact that the winter planting permits the crop to be grown in areas where chickpeas are nontraditional crop, there is every chance that the *Cicer Rhizobium* may either be absent or its population may be sporadic and too low for effective development of nodulation in the crop. Such a crop is likely to suffer from nitrogen deficiency unless attempts are made to introduce the *Rhizobium* along with the seed in these areas. Aspects of symbiotic dinitrogen fixation have been dealt with in details in another paper in this volume. Hence only the nitrogen nutrition aspect will be presented here.

Data in Tab. 5 emphasize the importance of an adequate mineral nitrogen supply in the medium in case the *Cicer Rhizobium* happens to be absent or too sporadic in the soil. The experiment was conducted at Tel Hadya during 1979-80 on a field where the native rhizobial count was rather low. The soil had an available phosphorus (Olsen's extractable P) of 7.5 ppm in the top 15 cm and 4.5 ppm in the 15- to 30-cm soil layer. The available potassium content was 438 and 425 ppm K in the two respective layers. The pH was 8.3 and the soil was poor in organic carbon content. It was evident from a visual evaluation of the crop that it suffered from nitrogen deficiency in all the treatments where artificial inoculation with *Cicer Rhizobium* was not done, except in the treatment which received 120 kg fertilizer nitrogen per hectare. Nodulation studies at the preflowering stage, when the symptoms of nitrogen deficiency were quite conspicuous, revealed that in the absence of inoculation, the nodulation was extremely poor (Tab. 5). The total number of leaves that senesced by that stage was also much higher in those treatments but reduced considerably when inoculation was done or fertilizer nitrogen was applied. More than 50% of the leaves produced by the preflowering stage had senesced by that time because of nitrogen deficiency in uninoculated plots. This reflected in reduced total shoot phytomass and ultimately in poorer yields. Inoculation was as effective as the application of 120kg N/ha in increasing the yield (Tab. 5).

Other than nitrogen, the mineral nutrient that is most likely to become limiting under field conditions in the region is phosphorus. Although chickpeas seem to

Table 5

Effect of fertilizer application and inoculation with chickpea *Rhizobium* on shoot dry matter yield at the preflowering stage, and grain and straw yield at maturity in winter-planted chickpea ILC 1929 at Tel Hadya, 1979–80.

Treatments	At preflowering stage					Yield (kg/ha) at maturity	
	Nodules/plant		No. of leaves/plant		Shoot		
	Number	Dry wt. (mg)	Total	Senesced	Dry wt. (g/plant)	Grain	Straw
Control	0.4	74	45.0	20.5	0.85	650	1150
50 kg P_2O_5/ha (P)	1.1	111	47.4	29.2	1.08	840	990
60 kg K_2O/ha (K)	0.9	137	50.6	24.9	1.23	960	1020
Inoculation (i)	14.8	195	53.7	11.7	1.49	1180	1780
I + P	17.8	241	53.8	14.2	1.50	1100	1480
I + K	18.3	248	59.9	16.4	1.75	1000	1500
I + P + K	18.5	303	61.9	14.6	1.93	910	1520
120 kg N/ha + P + K	0.6	51	51.4	15.8	1.24	980	1460
LSD (5%)	5.73	132.8	N.S.	6.51	0.61	262	391

have a much lower critical concentration value for the available soil phosphorus than the other grain legumes such as lentils and faba beans (Saxena 1979), their growth and yield can be substantially restricted under field conditions due to a deficient phosphorus supply. On a field at the ICARDA subsite in Kafrantoon, where the available soil phosphorus was 2.5 ppm P in the top 15-cm soil layer and 1.5 ppm in the subsequent 15-cm soil layer, conspicuous growth and nodulation response to phosphate application was obtained (Tab. 6) with winter-planted ILC 482 chickpeas in 1980-81 season. Because of the presence of a native population of *Cicer Rhizobium* at this site, there was no difference in the number of nodules per plant: however, the nodule dry weight was very much restricted by a shortage of phosphorus. Thus phosphorus deficiency resulted, indirectly, in a nitrogen deficiency by restricting symbiosis, which ultimately reflected in a poorer phytomass yield (Tab. 6). Application of 50kg P_2O_5/ha resulted in improved nodule dry weight as well as total shoot phytomass. This experiment illustrates the importance of an adequate phosphorus supply in permitting the development of a suitable symbiotic system.

The data presented in Tab.s 5 and 6 emphasize the importance of the fertility status in determining the need for fertilizer application. The fertilizer phosphorus had no effect on the crop at an available phosphorus status in soil of 7.5 ppm P, but improved the crop performance on a soil with an available phosphorus content of 2.5 ppm P. In both experimental sites, the available soil potassium

Table 6
Effect of fertilizer application and inoculation with chickpea *Rhizobium* on the nodulation and shoot dry matter per plant at the flowering stage of ILC 482 at ICARDA subsite Kafrantoon, 1980–81 winter planting.

Treatments	Nodules per plant				Shoot dry weight (g/plant)	
	Number		Dry weight (mg)			
	90 DAE	Flowering	90 DAE	Flowering	90 DAE	Flowering
Control	20.5	22.7	67.5	105.5	0.84	1.65
50g P_2O_5/ha (P)	25.6	25.8	176.0	175.[illegible]	1.68	3.30
60 kg K_2O/ha (K)	24.0	24.0	84.6	109.1	0.88	1.79
Inoculation (I)	25.6	22.7	94.4	116.8	1.01	1.79
I + P	27.7	23.5	167.7	176.7	1.59	2.79
I + K	27.4	28.9	94.6	111.7	0.91	1.83
I + P + K	29.1	26.6	211.1	157.2	1.98	2.99
100 kg N/ha + P + K	26.0	22.0	86.7	96.2	1.31	3.15
LSD (5%)	N.S.	N.S.	34.6	52.1	0.36	0.82

1. DAE = days after emergence.
NS = not significant.

appears adequate, therefore no response to fertilizer potassium application was obtained. However, the increased productivity of winter chickpea would also mean increased removal of potassium from the soil, particularly because little crop residues are returned to the soil in the cropping system in the region. For this reason, there would be a need to ensure some kind of a monitoring system for soil fertility status so that it may not become a major constraint to increased productivity.

Need for a periodic application of micronutrients might also arise in future, although at present there are no indications of the need for their application. In fact, winter chickpeas seem to have an advantage over the spring chickpeas in so far as iron nutrition is concerned. Several genotypes of chickpea on calcareous soils show a conspicuous deficiency of iron when planted in spring. This deficiency is induced because of the increased bicarbonate content in the soil in early spring. The winter-planted crop is able to accumulate adequate amount of iron in the plant by the time this stage is reached so that no deficiency is observed.

Weed Management

The winter-planted crop is likely to face a more serious weed problem than the spring crop as most of the weeds that could compete with the spring crop are killed by the preparatory tillage. In the winter-planted crop, the winter weeds emerge with the crop and thus offer serious competition to the crop. In a weed control study with the winter- planted crop, yield was reduced by about 42% when no weeding was done as compared with the hand weeded check. However, timely hand weeding or mechanical weed control may become difficult because of the winter rains. Therefore alternate weed management practices would be needed.

Development of an early crop canopy by the use of narrower row-spacing and higher seed rate can improve the competitive ability of the crop over the weeds. Also, use of preemergence herbicides such as Tribunil at 4 kg product/ha has given some control of annual weeds. The need for identifying more efficient selective herbicides is obvious. Realizing this, an International Weed Control Trial was started during the 1980-81 cropping season. This trial is being conducted in different parts of the region by the national program scientists. It includes three preemergence herbicides (chlorbromuron, methabenzthiazuron and terbutryne) at three rates of application, two hand weeding treatments and a weedy check. Data on weed count, at the onset of flowering of winter-planted chickpea, in one such trial at Tel Hadya during 1980-81 season revealed that chlorbromuron at 2 kg a.i./ha and methabenzthiazuron at 3.5 kg a.i./ha gave good control of weeds. The weed count was 5.9 and 3.4 weedplants/m^2 under the two herbicide treatments, respectively, as against 25.2 weedplants/m^2 under the weedy check.

Summary and Conclusion

Winter planting of chickpeas ensures that the vegetative and reproductive phases of the crop experience milder temperatures and better soil moisture regimes than the traditional spring-planted crop. In the whole range from early winter to early spring, advancing the date of planting results in increased yield over spring planting; the earlier the date, the higher the yield. The winter-planted crop responds better to increased plant population levels than the rainfed, spring-planted crop and a population level of 33.3 plants/m^2 seems to be optimum.

The productivity of the winter crop can be limited by a nitrogen deficiency in areas where crop is to be introduced for the first time. Inoculation with effective *Cicer Rhizobium* would, however, rectify this situation. On soils having 2.5 ppm or less of available soil phosphorus, the application of fertilizer phosphorus is advantageous. An application of 50 kg P_2O_5/ha placed below the seed row is adequate. Response to potassium applications has not been observed because of high available K content of the soil.

Weeds can be a major constraint to increased productivity in the winter-planted crop and can cause more than a 40% reduction in the yield. Mechanical weeding in the vegetative phase is of advantage but is difficult to practice because of winter rains. Several preemergence herbicides are being evaluated in the region to identify an effective one. There is a need for the studies to be carried out in different parts of the region on these and other agronomic aspects using the ascochyta blight resistant cultivars so that full advantage of winter planting could be realized.

References

HARRIS, H.C. 1979. Some aspects of the agroclimatology of West Asia and North Africa. Pages 7–14 *in* Food Legume Improvement and Development (Hawtin, G.C. and Chancellor, G.J. eds.), ICARDA, Aleppo, Syria and IDRC, Ottawa, Canada.

KASSAM, A.H. 1981. Climate, soil and land resources in North Africa and West Asia. Pages 1–29 *in* Soil, Water and Nitrogen in Mediterranean-type Environments (Monteith, J. and Webb, C. eds.). Martinus Nijhoff/Dr. W. Junk Publishers, The Hague.

ROBERTS, E.H., SUMMERFIELD, R.J., MINCHIN, F.R. and HADLEY, P. 1980. Phenology of chickpeas (*Cicer arietinum*) in contrasting aerial environments. Expl. Agric. 16: 343–360.

SAXENA, M.C. 1979. Importance of phosphorus in the balanced fertilization of some food crops in West Asia and North Africa. Phosphorus in Agric. 76:133–145.

SAXENA, M.C. 1980. Recent advances in chickpea agronomy. Pages 89–96 *in* Proceedings of the First International Workshop on Chickpea Improvement, 28 Feb–2 Mar 1979, ICRISAT, Patancheru, A.P., India.

SMITH, R.C. and HARRIS, H.C. 1981. Environmental resources and restraints to agricultural production in a Mediterranean-type environment. Pages 31–57 *in* Soil, Water and Nitrogen in Mediterrranean-type Environments. (Monteith, J. and C. Webb, eds.). Martinus Nijhoff/Dr. W. Junk Publishers, The Hague.

Discussion

F. El-Sayed

I am assuming that you have a good control of ascochyta blight in your studies since you had a local Syrian included in your study.

M.C. Saxena

In the first year of our studies the ascochyta blight was very insignificant and two protective sprays of the fungicide Dithane M-45 were given. In the next year, intensity increased and only partial protection was possible with fungicide. Presently we are only concentrating on the ascochyta blight resistant material.

S. Hanounik

Do you think that there are possible differences in the structure and number of chloroplasts among different chickpea cultivars (ILC 482 greener compared to ILC 202) which might make ILC 482 a more efficient genotype in utilizing light energy under rather short-day periods during winter, thereby yielding more?

M.C. Saxena

We have not carried out studies on the chlorophyll content of different genotypes. It is, however, observed that ILC 482 is lighter green in color than the Syrian Local and ILC 262, but not much different from ILC 202. ILC 202 is a tall type and has relatively lesser pods/plant than ILC 482, which might explain the differences in the yield. Differences in photosynthetic efficiency of different genotypes might exist and these should perhaps be studied in future.

M.V. Reddy

If we expect that the pressure on land use will increse as it is happening in the other parts of the world, and if we compare the production of winter and spring chickpeas per unit area per unit time, how much advantage is retained?

M.C. Saxena

Advancing the date of planting to winter would not cause any additional pressure on land. In fact because of increased productivity there might be a possibility that land area might be reduced. The duration for which the land will remain occupied with the crop will increase, but then only one crop per year is grown. Our observations on harvesting time of winter-planted crop revealed that you could harvest the crop 2–3 weeks before the spring crop and in good rainfall years there may be adequate moisture in the profile to raise a short-duration summer crop after harvesting the winter chickpea. New short-duration crops such as mung bean *(Vigna radiata)* maturing in 60 days might be a good candidate. We will try it this season.

S. Hanounik

Do you feel that greater root developed during winter is a major factor that helps uptake of more nutrients and water in spring which in turn is reflected in higher yield?

M.C. Saxena

Our root studies do show that the winter-planted crop is able to develop lot more roots in the favorable environment than the spring crop and this should help in more uptake of nutrients and water to cope up with the requirement for improved growth. Studies on soil moisture extraction by midwinter- and spring-planted chickpeas during 1979–80, in collaboration with the SWAN group of the Farming Systems Program, did show that winter-planted chickpeas drew more moisture from deeper layers and extracted moisture from greater depth than the spring crop.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Physiological and Moisture-Use Studies on Growth and Development of Winter-Sown Chickpeas

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The adoption of a winter sowing agronomic practice has only become realistic under Syrian environmental conditions following the development of chickpea lines resistant to ascochyta blight. Winter sowing is likely to result in the vegetative and early reproductive phase of development taking place under cool, moisture assured conditions, thus deferring the onset of the period of high evaporative demand and consequent moisture stress to crop's later growth cycle. Potential productivity of winter-sown chickpeas should thus be enhanced in comparison with the traditional spring-sown ones.

However, the interactions between physical environmental factors, such as radiant energy interception, moisture supply and temperature, and growth and development are usually complex. This particular experiment is designed to investigate these interactions, to examine the intensity and timing of onset of the significant environmental constraints on potential chickpea productivity. In addition, the ascochyta blight resistant lines can currently be subdivided in terms of their branching morphology being either of an erect or spreading habit. Such morphological differences may well result in genotype-environment interaction and in broad terms these are considered in this experiment.

Methodology

One line representing each morphological group was selected, for the erect group – ILC 72 and for the spreading group – ILC 482. These lines were handplanted in early November 1980 at a rate sufficient to achieve what is currently considered to be optimum stand density, i.e. 300,000 plants/hectare. An additional treatment was employed in the erect line in which a superoptimal density of 600,000 plants/ha was established to examine the effect of more rapid canopy

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development in the interception of radiant energy, moisture use and productivity. In all treatments, 60 kg/ha of P_2O_5 and a *Rhizobium* slurry was applied with the seed. This experiment was carried out at three sites which span the precipitation gradient in Aleppo Province, namely, Jindiress (500–550 mm), Tel Hadya (300–350 mm) and Brida (250–300 mm).

Samples were taken weekly from each site to provide a detailed growth analysis of crop performance. Throughout the growth season soil profile moisture status was monitored under all treatments using the neutron probe technique and meteorological parameters including total incoming solar radiation, precipitation, air temperature and pan evaporation were observed on site. Evapotransipration (E_t) for given time periods was determined by utilizing the data generated from the neutron probe studies according to the equation:

$$E_t = \Delta M + P - R - D$$

where ΔM is the change in total moisture stored in 0 – 180 cm profile in the period considered, P is the recorded rainfall, R is the soil surface runoff and D is the drainage below 180 cm depth. In this study, where all trial sites were flat, runoff (R) was not a problem and drainage below 180 cm depth did not occur (Fig. 1). Thus R and D could be ignored.

In addition, data are quoted in the paper for comparative purposes from a companion experiment in which ILC 482 was spring sown at the standard density at all three sites. All other management treatments were similar to the winter-sown crop.

Results and Discussion

Phenology

Microscopic apical dissection has revealed that the reproductive phase is initiated in ILC 482 approximately 10–14 days before it is initiated in ILC 72. From Table 1 it can be seen that there is a uniformity of photoperiodic values within each cultivar at initiation. This uniformity is not as closely matched in other parameters that might influence the timing of reproductive initiation, such as number of days from germination, degree day accumulation or morphological development (leaf number). Therefore it seems likely that in common with many other crops, a specific photoperiodic threshold exists for each cultivar which must be exceeded to permit initiation. These values appear to be close to 10 hours 57 minutes for ILC 482 and 11 hours 24 minutes for ILC 72 (both values exclude civil twilight).

Table 1
The timing of reproductive induction and physiological maturity in winter-sown chickpeas, 1980-81.

Site	Days G–I	Date of I	DD Acc. from G–I	Photo-period Hr.Min.	Leaf No.	Days I–M	Date of M	DD Acc. from I–M	Acc E_0 from I–M
ILC 482									
Jindiress	67	15/2/81	520	10.52′	7th	99	25/5/81	1401	430.4
Tel Hadya	70	18/2/81	563	11.00′	6th	96	25/5/81	1337	528.0
Brida	69	17/2/81	444	10.56′	6th	94	22/5/81	1320	469.8
Khanasser*	55	18/2/81	401	11.00′	4th	97	26/5/81	1468	588.1
Mean	65.3		482	10.57′		96.5			
ILC 72									
Jindiress	80	1/3/81	644	11.24′	8th	95	4/6/81	1506	466.3
Tel Hadya	79	28/2/81	655	11.21′	9th	93	1/6/81	1403	585.0
Brida	82	3/3/81	566	11.26′	8th	98	9/6/81	1610	637.1
Mean	80.3		622	11.24′		95.3			

G = Germination, I = Initiation, DD Acc. = Degree Day Accumulation (Mean air temperature in °C), M = Physiological maturity.
* = Additional information obtained from associated rotation trial

Canopy Development and Drymatter Production

Crop drymatter production is directly dependent upon the amount of radiant energy intercepted by the crop canopy. Considerable variations were observed at all sites within the peak values achieved by the active crop photosynthetic surface (green area index, Table 2). In this regard the densely planted ILC 72 treatment consistently developed its canopy faster, and to a greater extent, than standard density plantings of either cultivar. At the standard density the spreading cultivar (ILC 482) generally achieved higher values than the erect cultivar ILC 72. However, it was only at Jindiress that the green area index values were sufficient to achieve an effective canopy cover. Green area index values need to be greater than four if the canopies are to approach full closure.

Maximum drymatter production values (Table 2) reflect the trends in canopy development previously outlined. However, the differences in proportion between maximum green area index and maximum drymatter production values for Jindiress (max. DMP = approx. 1.67 max GAI) and for Brida suggest that a reduction in the efficiency of conversion of intercepted radiation into dry matter may have occurred. This possibility can ony be confirmed by a more sophisticated analysis which is currently ongoing, but for which results are as yet unavailable.

Table 2
Canopy development and drymatter production of winter-sown chickpeas, 1980–81.

Site	Maximum [1] Green Area Index (GAI)	Maximum [1] Above Ground Drymatter Production (DMP t/ha)	DMP ÷ GAI
Jindiress			
ILC 482	4.7	7.9	1.69
ILC 72	4.4	7.2	1.64
ILC 72 (Dense [2])	5.4	9.1	1.68
			$\bar{X}$ = 1.67
Tel Hadya			
ILC 482	2.6	3.6	1.38
ILC 72	1.9	3.3	1.74
ILC 72 (Dense [2])	3.0	4.7	1.56
			$\bar{X}$ = 1.56
Brida			
ILC 482	1.7	2.5	1.47
ILC 72	1.3	1.9	1.46
ILC 72 (Dense [2])	1.9	2.7	1.42
			$\bar{X}$ = 1.45

1. Values extracted from curves fitted by hand.
2. Stand density approximately 600,000 plants/ha.

Evapotranspiration and Water-Use Efficiency

Accumulated moisture use data are presented in Table 3 for all treatments at the three sites. Accumulated pan evaporation (E_0) and rainfall are also presented. Total E_t between germination and maturity (95% crop yellowing) is calculated, and utilizing final harvest data the water-use efficiencies (WUE) are given for each treatment for both total biological yield and seed yield.

All treatments (at a given site) had very simliar accumulated E_t values from germination through until early March. This includes the spring-sown ILC 482 crop which until mid-March (75% emergence) could effectively be considered as weed-free fallow plots. This similarity of E_t of winter-planted crops compared with evaporation from a bare soil (E_s) during the cool winter months has also been noted for other crops (e.g. wheat, barley, lentils, faba beans). During the winter, when crop leaf areas are low and the soil surface is frequently rewetted, E_s is the dominant component of E_t and it is only in spring, when crop leaf area in-

Table 3

Accumulated water use by spring- and winter-planted chickpea at three locations in northern Syria, (mm, Germination-Maturity), 1980–81.

JINDIRESS

Treatment	2/1	22/1	4/2	5/3	22/3	8/4	26/4	11/5	1/6	14/6	Maturity date	Total Et. Germ. → Mat.	WUE (1)	WUE (2)
ILC 72 (Dense*)	50	89	99	142	172	231	315	390	443	454	3/6/81	445	18.83	7.28
ILC 72	47	93	106	145	172	225	292	379	449	455	4/6/81	450	14.80	5.93
ILC 482	46	94	104	139	165	221	302	377	424	428	25/5/81	422	18.75	9.95
ILC 482 (SS)	48	93	107	145	163	204	231	294	384	413	14/6/81	413	7.97	4.55
E_o	49	91	119	185	250	324	410	496	617	744				
Rainfall †	120	237	274	338	359	401	413	456	456	456				

TEL HADYA

Treatment	22/1	13/1	29/1	1/3	31/3	13/4	30/4	19/5	2/6	11/6	Maturity date	Total Et. Germ. → Mat.	WUE (1)	WUE (2)
ILC 72 (Dense*)	17	48	71	110	159	189	259	299	317	319	3/6/81	317	12.21	4.35
ILC 72	17	51	73	108	152	180	250	296	313	316	1/6/81	311	10.16	4.28
ILC 482	18	52	74	108	151	173	244	299	311	311	25/5/81	311	11.42	6.73
ILC 482 (SS)	16	52	71	109	144	154	194	251	290	300	8/6/81	297	5.25	2.69
E_o	26	59	82	158	281	350	477	623	775	989				
Rainfall †	70	158	189	247	298	305	325	351	357	357				

BRIDA

Treatment	31/12	20/1	8/2	3/3	16/3	2/4	23/4	7/5	21/5	9/6	Maturity date	Total Et. Germ. → Mat.	WUE (1)	WUE (2)
ILC 72 (Dense*)	14	34	57	82	110	153	200	233	253	262	9/6/81	262	8.13	1.07
ILC 72	16	35	57	80	107	150	189	244	247	256	9/6/81	256	6.21	1.21
ILC 482	15	34	56	77	106	147	195	226	250	257	22/5/81	252	9.37	3.97
ILC 482 (SS)	14	37	58	82	102	130	162	207	236	249	5/6/81	246	5.57	3.01
E_o	35	61	100	148	197	268	369	478	583	786				
Rainfall †	86	115	125	174	184	223	232	274	277	277				

WUE (1)= kg/ha/mm. Total Biological Yield (above ground). *= Stand density approximately 600,000 pl/ha.
WUE (2)= kg/ha/mm. Seed Yield. † = Rainfall accumulated from onset of season. SS =Spring-sown crop from companion experiment.

creases rapidly and rainfall frequency decreases, that measurable differences in E_t and E_s occur. This is an important point when comparing winter and spring grown chickpeas since all root and shoot growth during winter is thus effectively "free" in terms of moisture use.

In March, April and May there was little difference in evapotranspiration between winter-sown crops at a given site, although the densely planted ILC 72 treatment tended to use more water than the standard density treatments. During this period E_t of winter-sown crops was significantly greater than the spring-sown crops at all sites.

As winter-sown crops approached maturity at the two drier sites (Tel Hadya and Brida) total E_t values between germination and maturity were found to be very similar in spite of the earlier maturity date of ILC 482. Nevertheless, densely planted ILC 72 continued to have a slightly higher total moisture use than either of the standard density treatments. In addition, at these two sites the final total moisture use of the spring-sown crop was similar (though sightly lower) to the winter-sown crops. In contrast, at the wettest site (Jindiress) where considerably more moisture was stored in the soil profile (Fig. 1A, B), the winter-sown longer maturity ILC 72 used significantly more moisture than both the winter- and spring-sown ILC 482. This point is discussed in more detail in the next section in which depth and efficiency of moisture extraction by chickpeas are considered.

Utilizing the final harvest data (Table 7) the water-use efficiency (WUE) of both total drymatter and seed production was calculated in terms of kg/ha/mm of moisture used. Considering WUE of total drymatter production, it can be seen from Table 3 that the densely planted ILC 72 and winter-sown ILC 482 treatments achieved very similar WUE values at any given site, but were higher than the standard density ILC 72 treatment. All winter-sown crops achieved much greater WUE values than those obtained for the spring-sown crops, particularly at the two wettest sites, Jindiress and Tel Hadya.

In terms of seed yield also, the winter planting of ILC 482 achieved a far higher water-use efficiency than the spring sowing resulting in a 119, 150 and a 32% increase in WUE at Jindiress, Tel Hadya and Brida, respectively. Due to the very different harvest index of the erect and spreading cultivars, the spreading cultivar gave a consistently better WUE than the erect types at all sites.

Comparing the WUE for an individual treatment across sites for both total drymatter production and seed yield, it is interesting to note the general decrease in WUE as one moves from wettest to driest site. This is partly due to differential stress during the period of potential flower and seed abortion resulting in a tendency for lower harvest indices at the drier sites, but it is likely to be attributed more to the differential ground cover achieved at each site. The moisture loss due to E_s (soil surface evaporation) can be calculated on a daily basis from the empirical formula:

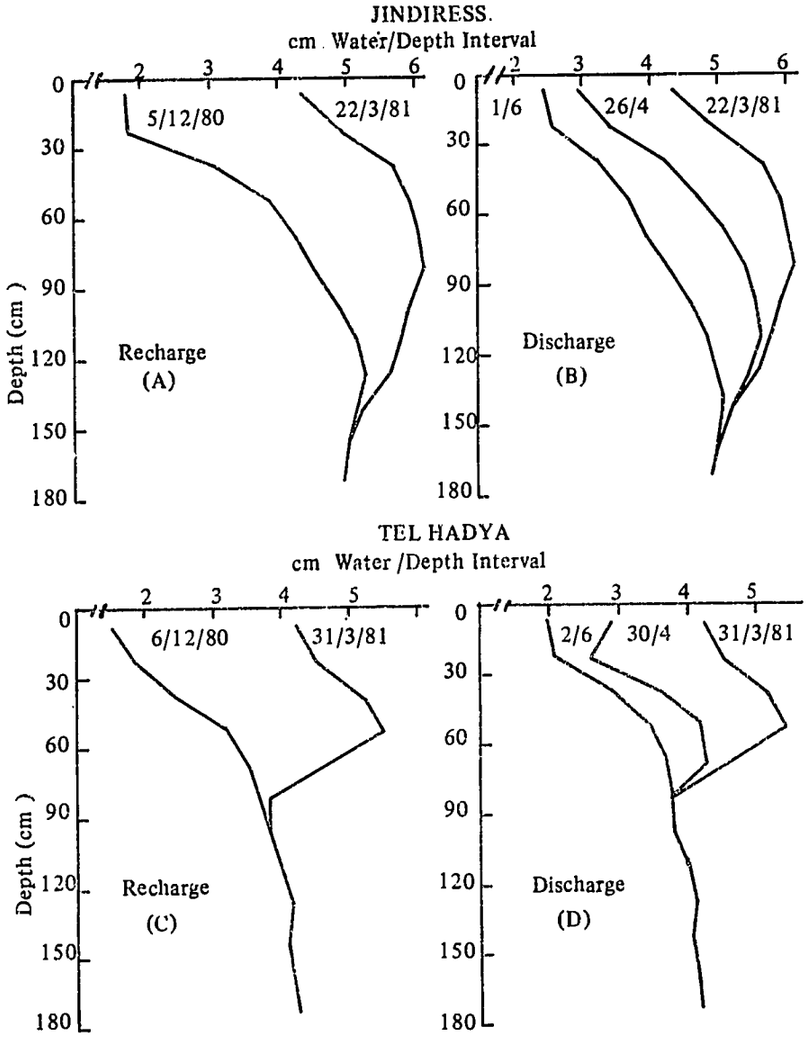
$$E_s = \frac{1}{t} \times (1 - \alpha) \times E_o$$

where t is the number of days since it last rained, E_0 is the evaporative demand and α is the fraction of ground cover. This formula demonstrates the importance, not only of frequency of rainfall, but also the fraction of ground cover in determining how much moisture loss in the evapotranspiration term is due to soil evaporation. We have previously noted the much greater green areas that were obtained at the wetter sites (i.e. maximum values of 4.7, 2.6 and 1.7 for ILC 482 at Jindiress, Tel Hadya and Brida, respectively), and the implications that this has on ground cover and radiant energy interception. Thus a progressively greater proportion of the evapotranspiration loss occurred as soil evaporation as one moved to the drier sites. Such moisture loss in not associated with assimilate production and would result in lower WUE values.

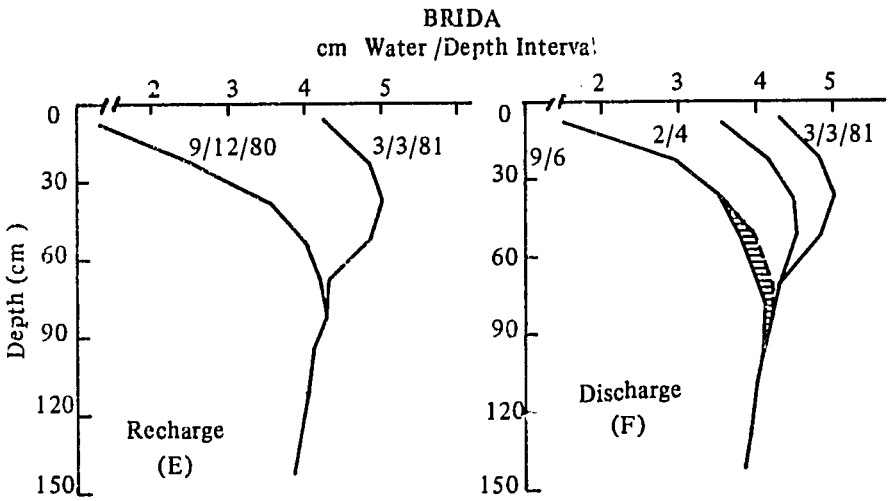
Depth of Moisture Extraction by Chickpea

In traditional chickpea-growing areas chickpea crops usually follow wheat in the local three course rotation system of wheat-grain legume (lentil or chickpea)-summer crop. At Jindiress and Tel Hadya, the trial was planted within this rotation, but at Brida, the land was fallowed in the previous season. Previous studies have shown that by the time the wheat crop reaches maturity, it has taken up all the "extractable" soil moisture within the rooting profile, and that at harvest very little moisture remains available for uptake. Further, slow loss of moisture occurs by upward movement and surface evaporative loss during the summer months. Thus during the next season only soil depth intervals which become recharged by current rainfall will contain moisture which is available for uptake by the chickpea crop.

The distribution of soil moisture during profile recharge and discharge is given in Figure 1A, B, C, D, E, F for winter-sown ILC 482 at the three sites as an example. It is clear that the chickpea crop was only able to extract moisture from the soil profile from depth intervals which had been recharged by the current season's rainfall. The results in Figure 1 are the mean of four replicates, but examination of individual replicates indicated that there was a large between-replicate variation in depth of profile recharge (Table 4) which resulted in parallel variations in the maximum depth of observed moisture extraction. This variation in depth of profile recharge is caused by large differences in the initial moisture status of the profile. This within-treatment variation in depth of moisture extraction was greatest at Jindiress, but also occurred to a lesser extent at Tel Hadya and Brida. It is interesting to note that at Brida, where the chickpea crop followed a fallow, much the same picture occurs (Figs. 1E and F). This indicates that there was very little additional moisture stored in the fallow which was available for the chickpea crop. In Figure 1F, the dotted line represents the



Figures 1A, B, C, D
Soil moisture recharge and discharge under winter-sown chickpea (var. ILC 482) at Jindiress and Tel Hadya in northern Syria.



Figures 1E, F
Soil moisture recharge and discharge under winter-sown chickpea (var. ILC 482) at Brida in northern Syria.

moisture status of the start of the season, and thus the shaded area represents moisture (6 mm only) stored under the fallow which was available for uptake by the crop.

At the two driest sites, Tel Hadya and Brida, the recharge front did not extend beyond 90 and 75 cm, respectively (Figs. 1C, D, E, F) and thus the rooting depth of the crop was greatly restricted compared with Jindiress. Thus at these sites there was little difference between treatments in the root distribution of the crop, even between winter and spring sowing. This is illustrated in Table 5a which presents the "extractable" moisture within discrete depth intervals under all treatments. "Extractable" moisture is defined as the difference between the maximum moisture content observed in any soil horizon and that at maturity. The ability of a crop to extract moisture from a given depth interval will depend largely upon the root proliferation with that depth interval, and thus "extractable" moisture values will reflect the root distribution. It can be seen from Table 5 that at Tel Hadya and Brida there was no meaningful difference between treatments. The difference between sites represent the different soil moisture charateristics of the two soils.

The same picture holds true at Jindiress when comparing the three winter-sown crops, but a contrasting picture emerges when comparing winter sowing with spring sowing. Table 4 indicates that the recharge front under spring-sown

Table 4
Effect of initial status of soil profile around individual access tubes on depth of profile recharge and depth of moisture extraction by chickpeas at Jindiress, 1980–81.

Treatment	Rep.	Moisture (cm) in 0–105cm profile (before first rains)	Depth of recharge (cm)	Depth of moisture extraction (cm)
ILC 72 dense	1	22.2	105–120	120–135
	2	24.8	135–150	135–150
	3	25.5	150–165	150–165
	4	26.6	135–150	150–165
ILC 72	1	23.9	120–135	120–135
	2	26.0	135–150	135–150
	3	21.7	90–105	90–105
	4	22.9	120–135	120–135
ILC 482	1	24.8	135–150	135–150
	2	24.3	120–135	120–135
	3	21.9	90–105	90–105
	4	24.7	120–135	135–150
ILC 482 (spring)	1		135–150	135–150
	2		165–180	105–120
	3		165–180	105–120
	4		150–165	105–120

Table 5
Extractable soil moisture in discrete depth intervals at Tel Hadya and Brida (cm/depth interval), 1980–81.

Depth	TEL HADYA					BRIDA				
(cm)	D.T.*	W.T.	W.S.	S.S.	Mean	D.T.	W.T.	W.S.	S.S.	Mean
0–15	2.87	2.87	2.87	3.00	2.90	2.83	2.83	2.41	2.83	2.73
15–30	2.71	2.61	2.55	2.43	2.58	1.92	1.95	1.76	1.86	1.87
30–45	2.53	2.37	2.40	2.32	2.41	1.50	1.51	1.42	1.41	1.46
45–60	1.99	2.05	2.02	2.02	2.02	0.98	0.81	1.01	1.00	0.95
60–75	0.80	0.91	0.94	0.89	0.89	0.52	0.32	0.40	0.34	0.40
75–90	0.07	0.05	0.04	0.07	0.06	0.13	0.07	0.11	0.28	0.15
Total	10.97	10.86	10.82	10.73		7.88	7.49	7.11	7.72	

D.T. = ILC 72 (600,00 p./ha)
W.T. = ILC 72
W.S. = ILC 482
S.S. = ILC 482 (600,00 p./ha)

crops extended deeper than under winter-sown crops, but that moisture extraction did not occur to the same depth. This is presented in more detail in Figures 2A and 2B, which show the temporal distribution of moisture within discrete depth intervals under winter- and spring-sown chickpea at Jindiress. Here it can be seen that under winter-sown ILC 482 recharge in any given horizon reached a maximum value, but due to the established root system and crop canopy, the recharge pattern reverted rapidly to discharge from early March onwards. This uptake of moisture by the crop greatly reduced redistribution of moisture by slow drainage into deeper horizons. In contrast, under spring-sown chickpeas where the crop canopy and root system had not developed, depth intervals became recharged and maintained high contents of soil moisture for several months before discharge occurred in April. Under these conditions, much greater moisture redistribution by slow drainage occurred, and recharge was observed to

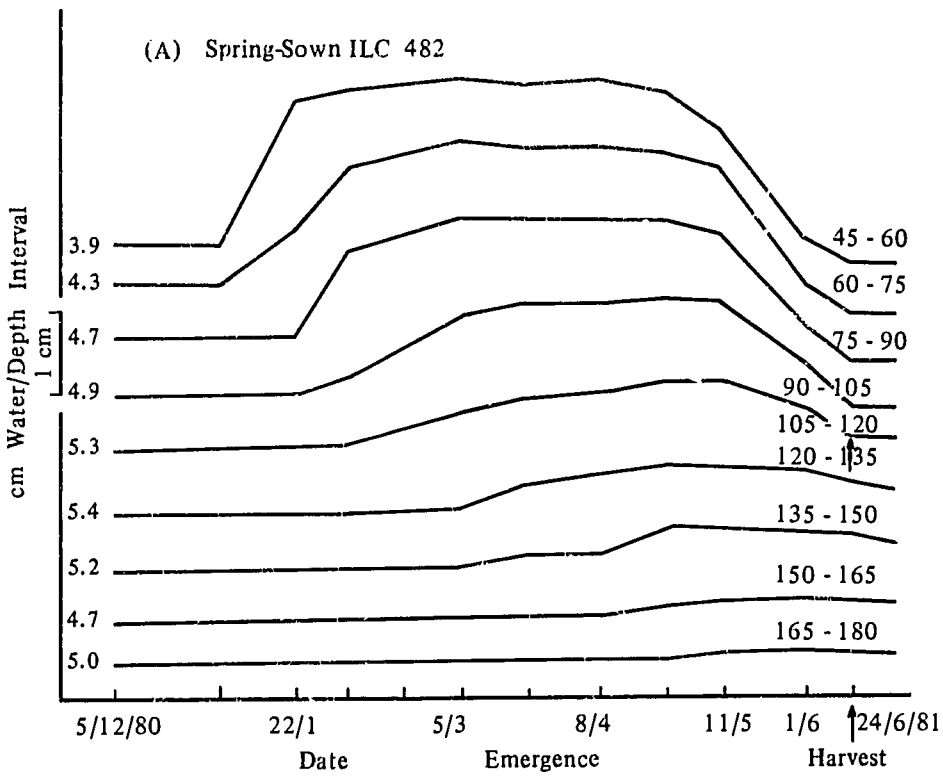


Figure 2A
Temporal distribution of moisture within discrete soil horizons under spring-sown chickpea at Jindiress, 1980–81.

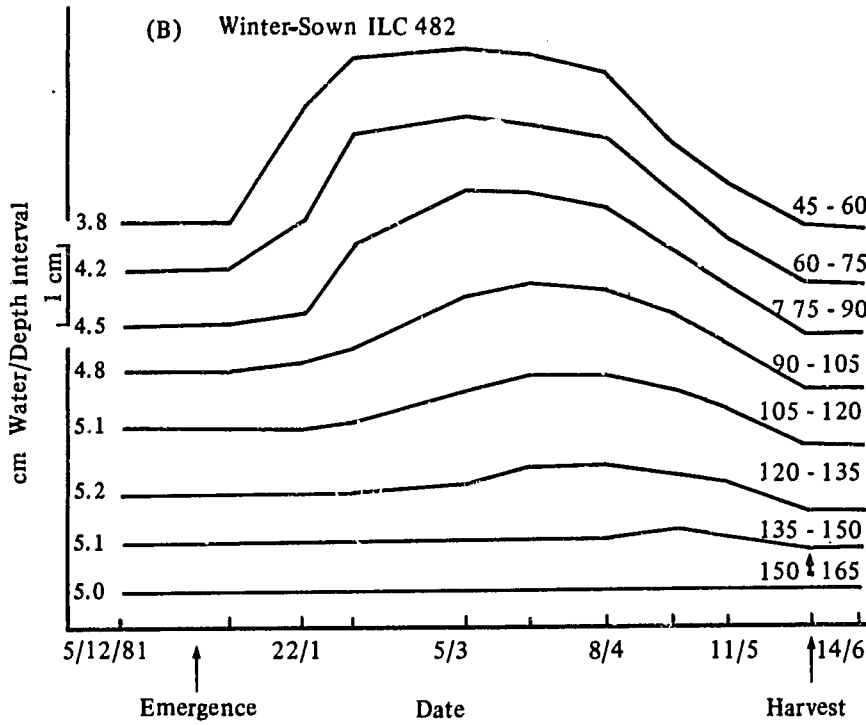


Figure 2B
Temporal distribution of moisture within discrete soil horizons under winter-sown chickpea at Jindiress, 1980–81.

occur as deep as 165–180 cm as compared with only 135–150 cm under the winter-sown crop.

It has been previously shown that careful examination of the temporal distribution of moisture within discrete depth intervals can be a powerful tool in distinguishing between moisture loss from a horizon by slow drainage and crop uptake. Attention is paid to the period when the crop matures. A clear discontinuity in the slope of the line at this time indicates that root uptake has ceased (see all depth intervals to 120 cm) under spring-sown chickpea (Fig. 2A), but no change in the slope at maturity indicates continuing slow drainage loss (see depth intervals 120–180 cm in Fig. 2A). The maximum depths at which this clear discontinuity is seen is marked with arrows in Figure 2A, B and it is apparent that the winter-sown crop extracted moisture from as deep as 135–150 cm depth compared with only 105–120 cm depth under the spring-sown crop. This suggests that where root development is not restricted by the depth of the recharge front

(as at Jindiress), the winter-sown crop will develop a deeper rooting system than a spring-sown crop.

However, data presented in Table 6 which gives the "extractable" moisture under both winter- and spring-sown chickpeas at Jindiress demonstrates that although the winter-sown chickpea roots deeper, there is no difference in root proliferation with depth intervals to 105 cm. Thus the greater root development of winter-sown chickpea at Jindiress only increases the "extractable" moisture available to crop uptake to a small extent.

Table 6
Extractable soil moisture in discrete depth intervals under winter (W.S.) and spring (S.S.) sown chickpeas at Jindiress (cm/depth interval), 1980–81.

Depth (cm)	W.S.	S.S.
0–15	2.56	2.82
15–30	2.61	2.58
30–45	2.58	2.57
45–60	2.31	2.42
60–75	2.16	2.23
75–90	1.92	1.87
90–105	1.34	1.38
105–120	0.95	0.69
120–135	0.63	
135–150	0.16	
Total	17.21	16.56

Yield and Yield Components

The potential productivity of winter-sown chickpeas in northern Syria appears to be highly satisfactory under favorable environmental conditions such as were experienced at Jindiress (Table 7). Seed yields of 3–4 t/ha at current local prices would ensure a considerable profit to the grower. However, it is clear from the data in Table 6 that environmental conditions have a significant effect on achieved yield and additionally, cultivar and genotype-environment interactions, all combine to influence productivity levels.

Stress Factors Associated with Inadequate Moisture Supply

The yields of individual cultivars (Table 7) showed that a reduction in the total

Table 7
Productivity of winter-sown chickpeas

Site	Seed Yield† (t/ha)	Total above-ground drymatter at harvest (t/ha)	Harvest Index	100-seed weight	Pods per plant (No.)	Empty pods (%)
Jinderess						
ILC 482	4.20	7.91	0.531	24.7	72.6	17.2
ILC 72	2.67	6.66	0.401	25.0	44.7	22.5
ILC 72 (Dense*)	3.24	8.38	0.387	25.7	24.9	21.5
ILC 482 (SS)	1.88	3.29	0.571	23.4	31.1	22.4
Tel Hadya						
ILC 482	2.09	3.55	0.589	27.0	27.6	4.6
ILC 72	1.33	3.16	0.421	26.5	17.0	12.7
ILC 72 (Dense*)	1.38	3.87	0.357	25.7	9.3	13.2
ILC 482 (SS)	0.80	1.56	0.512	23.21	17.1	17.5
Brida						
ILC 482	1.00	2.36	0.424	28.1	13.7	6.7
ILC 72	0.31	1.59	0.195	20.5	9.6	46.4
ILC 72 (Dense*)	0.28	2.13	0.131	17.3	5.6	51.9
ILC 482 (SS)	0.74	1.37	0.540	19.2	17.1	20.1

† = Seed yields adjusted for minor insect damage.
* = Stand density approximately 600,000 pl/ha.
(SS) = Spring-sown crop from companion experiment.

precipitation received in the season from 456 mm to 277 mm (Table 3) reduced seed yield considerably. The mechanisms by which this gross effect is experienced are somewhat diverse and complex, and precise quantification of individual effects is, at this stage in the experimental analysis, difficult to achieve. However, two mechanisms appear to be prominent in causing yield reduction.

1. It has been shown in Table 2 that maximum canopy development was severely affected by location and that complete cover was only achieved at Jindiress. This directly implies that the proportion of incident radiant energy intercepted was reduced and total drymatter production levels were in consequence lower at the two drier sites. The reduced canopy development may have resulted directly from an inability in the crop to meet short-term atmospheric demand for moisture, thus experiencing a consequent retardation of photosynthetic activity. Alternatively, the increasing dryness of surface soil layers may have required crop moisture withdrawal from deeper soil layers deficient in essential nutrients and thereby imposing nutrient stress. It is likely that both effects would occur simultaneously and the net result is a

reduction in the size of the crop's pod-bearing structure and the level of stored photosynthate available for pod filling. The influence of both factors is integrated in the water-use efficiency values which we have shown in the previous section to be severely reduced in the drier locations.

2. It has been also indicated in an earlier section that ILC 482 is an earlier maturing cultivar than ILC 72. This early-maturing characteristic will generally confer upon ILC 482 a yield advantage over ILC 72 under northern Syrian Mediterranean environmental conditions for two reasons. First, early maturation is achieved without a reduction in the duration of the reproductive phase which is critical in a crop with a potentially indeterminate growth habit. Second, as crop evaporative demand increases significantly in the late spring-early summer period (the period of crop reproductive development), an early-maturing cultivar will be exposed to less extreme levels of moisture stress and these will be deferred to a later stage in its phenological development. Accumulated totals of pan evaporation for the reproductive phases of the two cultivars (Table 1) show that there was significantly greater potential evapotranspiration during the reproductive phase of ILC 72 than that experienced by ILC 482 at all sites.

The beneficial effect of this early maturing characteristic on seed yield was most clearly demonstrated at Brida where seed yields in ILC 72 were much reduced below the values of 0.7–1.00 t/ha which might have been expected to be obtained from the maximum drymatter production achieved (Tables 2 and 7). This is illustrated by the atypical harvest index values shown by both density treatments. The likely cause of this reduced seed yields appears to have been moisture stress induced flower and seed abortion which seems to have been at supercritical values during the sensitive flowering and early pod formation phase. Winter-sown ILC 482 appears to have been less affected by this stress as it retained a higher number of pods per plant and managed to fill almost all the pods set which was quite clearly not the case in ILC 72 (percentage of empty pods, Table 7). However, the reduction in harvest index in winter-sown ILC 482 at Brida from the values of greater than 0.5 achieved at the other two sites suggests that a 20% yield reduction occurred even in this cultivar from specific stresses imposed in the reproductive phase of development. In ILC 72 the data shown for 100-seed weight in Table 7 further suggest that moisture stress effects at Brida restricted the adequate filling of pods from either concurrently derived or translocated photosynthate. As this was not the case in winter-sown ILC 482 it appears to be further evidence to suggest the beneficial effects of early maturity which allows escape from the most severe effects of moisture stress.

Morphological and Crop Density Factors

The results given in Table 6 suggest that, under favorable or intermediate environmental conditions (Jindiress and Tel Haya, respectively), the erect form of chickpea (ILC 72), when winter sown at 30 plants/m^2, is less productive than the spreading form (ILC 482) in both drymatter and seed yield. This is particularly true in the latter case, where, though development of a tall stem structure may reduce canopy size somewhat (Table 2), it has a significantly greater effect in reducing the conversion efficiency of dry matter to seed yield. This is expressed by harvest index values for the erect cultivar close to 0.41 as compared with values close to 0.55 for the winter-sown spreading cultivar. This reduced efficiency of drymatter conversion to seed yield is exemplified in the yield results for the densely planted treatment (60 plants/m^2). The results given in Table 7 show that this treatment achieved comparable or greater drymatter production than ILC 482 but its seed yield was consistently lower. Also, harvest index was apparently reduced by increased density in ILC 72 thereby exaggerating the cultivar differential. This suggests that increasing plant density in erect cultivars may not necessarily be an efficient manner by which yield levels can be increased, but it is clear that higher density plantings would probably outyield erect cultivars planted at current standard density (30 plants/m^2) when moisture conditions prove to be favorable (Table 7).

Conclusion

Winter planting of chickpea crops in the wetter regions of northern Syria is likely to be extremely productive. Even at the drier sites, such as Brida, where chickpeas are not currently grown, at current market prices, this crop would be competitive with the traditionally grown barley. Nevertheless, our data do suggest that this crop is sensitive to moisture stress and this could lead to greater instability of yield and farmer income than is associated with barley. It is likely that further research efforts can identify crop cultivars and management practices which reduce the risk factors involved. The results of this study suggest that breeders should select very early maturing cultivars for the drier regions and that agronomists should pay further attention to the interaction between moisture supply, canopy development and productivity.

Discussion

G.C. Hawtin

You raised a note of caution on the production of winter chickpeas following wheat (ref. Fig. 1), yet this is the normal practice in lentils. Do you have any evidence of differences between lentils and chickpeas in their rooting patterns following fallow or a cereal?

P. Cooper

No, the point of interest is that observations so far show that a legume crop (lentil, faba bean, chickpea) rooting depth coincides with the depth of penetration of the current seasons wetting front. The depth of penetration of the wetting front is very much related to the pattern of moisture use by the crop in the preceding season. The implications of this observation on moisture-use patterns, growth, nutrient uptake, yield etc. are not clear.

P. Cooper

What is the value of chickpea fodder compared with lentil? Because winter chickpea will produce much greater weight of fodder as well as yield.

D. Nygaard

Value is about 20 piasters for chickpea compared with 60 piasters for lentils.

M.C. Saxena

Moisture extraction pattern for Tel Hadya shows that the extraction is not occurring below 75 cm in spite of the fact that moisture content there is higher than the values to which the moisture content could be reduced in layer above 75 cm. Does that show that a factor other than moisture content is restricting the growth of root in Tel Hadya? Same seems to be the case in Brida as well.

P. Cooper

Not necessarily. As roots become sparser in distribution at depth, their ability to "extract" moisture decreases due to the length of "diffusion pathway" from soil and root surface. Thus even, with roots going down to 150 cm, you will always observe greater water left at depth at crop maturity.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Nodulation Aspects of Winter-Planted Chickpeas

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Unlike faba beans and lentils, chickpeas are normally grown in Syria and in several other West Asian countries as a spring-planted crop. Efforts are currently being made to introduce chickpea as a winter crop because of higher yield potential than the spring-planted crop. Within the framework of research to improve the productivity of winter chickpeas, studies were initiated to examine the different nodulation aspects of winter-planted chickpeas at ICARDA farm at Tel Hadya in northern Syria. Some results are presented below.

Response to Inoculation with Different Strains of *Rhizobium*

Inoculation experiments were conducted during the 1978–79 and 1979–80 growing seasons mainly to identify effective strains of *Rhizobium* suitable for winter-planted chickpeas. Similar experiments were planted in spring season also, in the adjoining part of the field, in order to compare the performance of individual strains of *Rhizobium* during the winter and spring seasons.

In the 1978–79 growing season, the inoculation response to eight strains of *Rhizobium* (IC-26, 3889, Ca-7, Cp-20b, Cp-14b, Cp-5b, Cp-23b and Cp-12) was examined in a local kabuli type chickpea (cv. ILC 1929). In the 1979–80 growing season the inoculation response to eight strains of *Rhizobium* (IC-26, Cp-5b, IC-47, Cp-26a, Cp-32b, Cp-35a and Cp-37a) was examined again in the same host cultivar. Experiments were conducted under rainfed condition and the seasonal precipitation was 240 and 426 mm, respectively, in two seasons.

Plants were sampled at different stages of growth to assess nodulation and drymatter production before final harvest for grain yield was made. Nodulation and total drymatter production data obtained at early flowering stages are given in Table 1. The data for the inoculated treatments represent a mean for the effective strains of *Rhizobium* used for each of the experiments.

In general *Rhizobium* inoculation considerably increased the number of nod-

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Table 1
Nodulation and total drymatter yield per plant at flowering stage in winter (Win.) and spring (Spr.) planted chickpea during 1978–79 and 1979–80 and seed yield in 1978–79 as affected by inoculation with several strains of *Rhizobium* at Tel Hadya.

Treatments	1978-79								1979-80					
	Nodule No./plant		Nodule dry wt. (mg/plant)		Total dry wt. (g/plant)		Seed yield (kg/ha)		Nodule No./plant		Nodule dry wt. (mg/plant)		Total dry wt.	
	Win.	Spr.	Win.	Spr.	Win.	Spr.	Win.	Spr.	Win.	Spr.	Win.	Spr.	Win.	Spr.
Uninoculated	14.2	3.1	90.7	5.4	6.9	3.7	1361	819	2.2	2.2	138.3	57.2	12.0	6.8
Inoculated	25.0	11.3	133.4	29.5	8.9	5.6	1587*	1110†	9.6	9.3	188.4	92.1	15.3	7.8
Uninoculated 120 kg N/ha	20.2	3.5	9.8	3.7	10.5	6.0	1629	1214	2.8	2.9	48.4	38.9	19.0	9.2

* Range for eight inoculum strains between 1446 and 1816 kg/ha
† Range for eight inoculum strains between 936 and 1256 kg/ha

ules and the nodule mass for both winter- and spring-planted crops. However, all strains of *Rhizobium* resulted in more nodules and nodule mass during the winter season than in spring, in both years. Although some strains caused very good nodule development in the winter season, these failed in spring. Some strains of *Rhizobium* (for example, IC-26 and Cp-5b) performed well during both winter and spring season. Even these strains produced only 35–75% nodule mass in spring as compared to the winter. It was also observed that in winter the plants formed more primary nodules and the secondary nodules were well distributed in the root system, whereas the spring-planted crop had fewer primary nodules which were located only in a portion of the roots immediately below the surface. This possibly resulted from the differences in the availability of moisture and/or soil temperatures during the two seasons. Application of inorganic nitrogen fertilizer to the plants considerably reduced the nodule mass development.

The drymatter production reflected the nodule development pattern of the plants (Table 1). Irrespective of the treatments, the plants produced more dry matter in the winter than in the spring. In the 1979–80 growing season, the plants generally formed more nodule tissues and total dry matter than in 1978–79, possibly because of more rainfall.

The winter-planted crop also produced more grain during 1978-79 than the spring-planted crop, i.e. 33–66% more, depending on the *Rhizobium* strain. Reliable yield data could not be obtained during the 1979–80 growing season because the winter-planted crop was severely damaged at the pod filling stage by ascochyta blight, in spite of repeated spraying with fungicides, and the spring-planted crop was damaged by birds at the early seedling stage.

These results indicate that planting chickpeas in winter results in better nodulation, possibly because of more available moisture in the soil profile. Better nodulation might partly be responsible for higher grain yield in winter-planted chickpeas.

Response to Inoculation with Single, Double and Multiple Strains of *Rhizobium*

The results described above showed that artificial inoculation greatly increased both nodulation and yield of winter-planted chickpeas. However, the growing season of winter-planted chickpea is characterized by two contrasting weather conditions, i.e. very cold wet weather at early vegetative stage which changes rapidly to hot dry weather during pod filling and maturity stage. It was thus thought necessary to compare the performance of single versus multiple strains of chickpea *Rhizobium*. Accordingly, during 1978–79 growing season three strains of *Rhizobium* (3827, Ca-7 and IC-26) were used either singly or in combination with ILC 1929 chickpeas planted in winter (Islam 1980).

Inoculation with single strain (Ca-7 or IC-26) produced more nodules than the combination of strains (Table 2). Though the number of nodules differed considerably in the different inoculation treatments, the total nodule dry weight per plant remained more or less similar irrespective of the number of strains used. The plants inoculated with IC-26 alone or in combination with Ca-7 or with Ca-7 + 3827 produced higher grain yield. The other two strains alone or in combination did not affect grain yield when compared with uninoculated treatments. The combination of IC-26 with 3827 also had similar effect.

These results indicate that the presence of one effective strain as an inoculant is sufficient to produce adequate nodulation and to increase the yield of chickpeas and that the efficiency of such a strain can be lost by combining with a less effective strain. Therefore, it is suggested that an effective strain is identified by screening a large number of strains for each location.

Table 2
Nodule number, nodule dry weight, and grain yield of winter-planted chickpeas as affected by single, double, and multiple strain inoculants of *Rhizobium* at Tel Hadya, 1978–79.

Treatment	Nodule No./plant	Nodule dry wt. (mg/plant)	Yield (kg/ha)
Noninoculated	6.4	27.7	1801
3827	26.0	65.8	1966
Ca7	41.4	50.4	1855
IC-26	40.5	62.1	2335
3827 + Ca-7	24.4	65.8	1990
Ca-7 + IC-26	31.2	60.5	2330
3827 + IC-26	12.8	65.9	1860
3827 + IC-26 + Ca-7	51.1	68.5	2284
LSD (5%)	8.4	10.5	266

Response to Phosphate and Nitrogen Fertilizer Application

Field experiments were started in November 1980 to (i) determine the amount of phosphate fertilizers required for optimum nodulation and yield, (ii) study the effect of small amounts of nitrogen fertilizers on nodule production and yield, and (iii) identify superior strains of *Rhizobium* suitable for soils containing low and high levels of available phosphorus and nitrogen.

In one of the experiments, the influence of phosphorus fertilizer (triple super phosphate) applied at the rate of 0, 25, 50 and 75 kg P_2O_5/ha was investigated. In another experiment, the effect of nitrogen fertilizer (ammonium nitrate) applied at the rate of 0, 20, 40 and 60 kg N/ha was examined. Four strains of *Rhizobium*

(3889, IC-26, Cp-5b and Cp-37a) were used for both experiments. The crop in nitrogen fertilizer study received 60 kg P_2O_5/ha as a uniform dose. An ascochyta blight tolerant cultivar ILC 482 was used as a test crop.

Several harvests were made to assess the nodulation and growth but only the data for early flowering stage are presented (Table 3). The data for the inoculated treatments represent a mean for the four strains of *Rhizobium* used.

The uninoculated plants produced a few nodules and their numbers were little affected by either the application of phosphate or nitrogen fertilizers. The nodule weight increased with the addition of fertilizers up to 50 kg P_2O_5/ha and 40 kg N/ha. Beyond those amounts the nodule weights decreased.

Table 3
Development of nodulation and growth in winter-planted chickpea (ILC 482) under different phosphate and nitrogen regimes at Tel Hadya, 1980–81.

Treatment	Rate (kg/ha)	Nodule No./plant		Nodule dry wt. (mg/plant)		Total dry wt. (g/plant)	
		Uninoc	Inoc.	Uninoc	Inoc.	Uninoc	Inoc.
P_2O_5	0	3.1	13.3	262	601	4.53	5.94
	25	4.0	18.8	275	615	4.59	6.58
	50	3.4	16.2	381	619	4.36	6.89
	75	4.5	14.1	325	694	5.80	7.29
N	0	3.1	19.9	77	492	3.81	6.57
	20	4.4	17.1	208	411	5.02	6.29
	40	3.9	13.6	207	407	6.54	6.72
	60	2.9	14.8	285	314	7.88	6.80

Inoculation with the different strains of *Rhizobium* considerably improved nodulation. Again the nodule numbers were less affected by additions of both phosphate and nitrogen fertilizers. Increasing the rates of phosphate fertilizer increased the nodule mass development. However, the reverse was true when the amount of nitrogen fertilizer was increased.

Addition of phosphate fertilizers up to 50 kg P_2O_5/ha to the uninoculated plants had little effect on the plant drymatter production. Only addition of 75 kg P_2O_5/ha increased the dry matter production for the uninoculated plants. However, the inoculated plants responded steadily with the increase in phosphorus application rates, producing maximum dry matter at 75 kg P_2O_5/ha.

Drymatter production for the uninoculated plants increased when rates of application of nitrogen fertilizer were increased. Maximum drymatter was producted when 60 kg N/ha was applied. Nitrogen fertilizer application had, however, little effect on the drymatter production for the inoculated plants.

These results indicate that phosphorus fertilizer application is necessary to maximize nodulation of winter-planted chickpeas, whereas nitrogen fertilizer appliation could adversely affect nodulation. Yield data are still to come and it will be interesting to see whether the yield figures reflect the nodulation data.

Studies on Herbicides and Nodulation

The nodulation and nitrogen fixation in winter-planted chickpeas can be limited by the presence of many weeds. In recent years, hand weeding has become less economic in some countries of this region and chemical weed control may assume greater importance. Herbicides can, however, affect the *Rhizobium* adversely. The identification of tolerant strains will therefore be necessary. With this objective, an experiment was conducted during 1978–79 using five herbicides (Gesagard, 2 kg p/ha; Treflan, 1 liter p/ha; Alachlor, 3 liter p/ha; Metribuzine, 1 kg p/ha; and Tribunil, 4 kg p/ha) with winter-planted chickpeas (cv. ILC 1929) and a mixed culture of three strains of *Rhizobium* for inoculation.

Metribuzine and Alachlor completely killed the plants. Of the other three herbicides, only Tribunil gave a good control of weeds, without much affecting plant growth and nodulation. Artificial inoculation partially removed the inhibitory effects of herbicides on nodulation thus giving an indication that strains of *Rhizobium* could be identified that might tolerate the herbicide and result in better nodulation and grain production.

To study this aspect more thoroughly the performance of four strains of *Rhizobium* (3889, IC-26, Cp-5b and Cp-37a) was evaluated on winter-planted chickpeas (CV. ILC 1929) under Tribunil (4 kg p/ha) treatment during 1979–80. The results showed that the strains of *Rhizobium* differed considerably in their tolerance to Tribunil as assessed in terms of nodulation. The strain 3889 performed the best under Tribunil treatment and produced significantly more nodule mass compared with the hand weeded and inoculated treatments (Table 4). The effect is not reflected in grain yield because some of the plots were affected by ascochyta blight at a later stage of growth and influenced grain production considerably.

Conclusion

In the presence of effective *Rhizobium* strain, nodulation in winter-planted crop is better than in the spring-planted crop. For the full realization of yield potential of winter planting, it is necessary to ensure that the appropriate strain of chickpea *Rhizobium* is present in the rhizosphere, which can best be achieved by artificial inoculation.

Table 4
Effects of *Rhizobium* inoculation and weed control treatments on nodulation and grain yield of chickpea and the development of weed biomass at Tel Hadya, 1979–80.

Treatment	Nodule No./plant	Nodule dry wt. (mg/plant)	Weed biomass (kg/ha)	Grain yield (kg/ha)
Uninoc + Unweeded	5.2	121.1	5987	1123
Uninoc + Hand weeded	4.7	190.8	Nil	1947
3889 + Hand weeded	24.7	214.4	Nil	1739
Uninoc + Tribunil	5.8	215.4	593	1322
3889 + Tribunil	17.2	241.7	497	1408
LSD (5%)	2.6	19.4	273	242

Reference

ISLAM, R. 1980. Effect of single, double, and multiple strains of *Rhizobium* on nodulation of a kabuli type chickpea. International Chickpea Newsletter 2:17–18.

Discussion

M.V. Reddy

The reflection of the amount of nodulation in yield in certain genotypes and not in others indicates a strong genotype and *Rhizobium* interaction. If the contribution of microbiology in crop improvement is to come through, it is in this area and hence more work should be carried out. The reason for differential response of genotypes to *Rhizobium* could be that the genotypes that respond to inoculation are more efficent in nitrogen use or more responsive to nitrogen. This can be tested by growing responsive genotypes under nodule-free conditions in nutrient solution.

R. Islam

You are right. More emphasis has to be given to the host genotype – *Rhizobium* strain interaction in future. Existence of non-nodulating cultivars in chickpeas is yet to be reported. Hence straight comparison of nitrogen fixation and fertilizer nitrogen use will not be possible at the present moment. However, evidence is available that some cultivars respond to artificial inoculation much better than others when native population is low. There it will be more interesting to see whether the yield of the low-yielding cultivars could be increased by inoculation with the effective strains of *Rhizobium*.

T.S. Sandhu

Is there any technique available which is nondestructive to assess the nodulation capacity of the chickpea plant? If so, it may be utilized in breeding for high nodulating genotypes with a given efficient and effective strain of *Rhizobium* as there is specificity between *Rhizobium* strains and host genotype.

R. Islam

Nondestructive techniques (Allontoin technique) are available for determining high nodulating ability for some crops, like soybean. Efforts are being made to use this for chickpeas. The last three years' research at ICARDA with chickpea has indicated that high and low nodulating character is very unstable, i.e. possibly not controlled by the host plant. It will be more appropriate to screen strains of *Rhizobium* which will be suitable to produce effective nodulation for a large number of cultivars.

P. Cooper

Does chickpea total drymatter production (as presented in many of your tables) reflect yield? How stable is harvest index (HI) for chickpea?

R. Islam

No, HI is not stable due to (a) disease and (b) stress factors during flowering.

N. Haddad

Since you find that Tribunil is reducing the nodulation, did you measure any reduction in yield due to the effect of this herbicide?

R. Islam

Yes, we measured the amount of yield loss caused by Tribunil. Tribunil actually reduces yield. But the effect of the herbicide was more pronounced on nodulation than on grain yield.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Screening Chickpeas for Cold Tolerance and Frost Resistance

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In the lowland areas (<1200 m altitude) of West Asia and North Africa, which are characterized by a warm continental Mediterranean climate, the thermal regime consists of cool (5–18°C) or cold (<5°C) winter with warm or hot summer (Kassam 1981). Unlike the plateau region (>1200 m altitude) where winters are very cold and the snow cover may persist for several months preventing any crop growth, the lowland zone experiences milder winter temperatures and the day time air maxima appear sufficient to promote photosynthesis in temperate species, thus permitting some vegetative growth during the winter (Harris 1979). From the start of autumn unitl the end of winter, radiation and temperature decline and in association with high humidity, low wind speed and increasing rainfall, the soil moisture content increases (Smith and Harris 1981). Thus, winter months under lowland conditions offer an opportunity for extending the potential growing season of a crop like chickpea which can produce a conspicuous increase in yield over that obtained from the traditional spring planting. That such yield advantages can actually be realized in the field with winter planting has been shown by Hawtin and Singh (1981) and Saxena (1979), provided the crop can be protected from the ascochyta blight. However, as the season progresses from November to January, the night temperatures often fall below 0°C in these areas and the day temperatures could be well below 5°C. Thus the winter-planted crop is liable to be exposed to varying degrees of cold stress in the early vegetative growth stage.

Also, throughout the region there is a risk of crop damage through sudden and late frosts during the preflowering and flowering period of a winter-planted crop. Based on the analysis of 13 years of daily temperature data for northern Syria, Harris (1979) showed that the timing of the last frost could range from the third week of March for Hama (35°08′N, 36°45′E, 309 m altitude) to the first week of April for Aleppo (36°11′N, 37°13′E and 392 m altitude) and the second week of

April for Tal Abaid (36°42′N, 38°57′E and 355 m altitude), at a frequency of at least once in every 13 years. Since the winter-planted crop at such a period would generally be actively photosynthesizing and making rapid growth, owing to a favorable radiation level and thermal and moisture regimes, a sudden exposure to frost could have a very serious consequence for the crop.

To ensure the future success of winter planting of chickpeas in the lowland Mediterranean region, it is necessary to develop cultivars that have tolerance not only to ascochyta blight but also to cold (T, <5°C) during the winter months, and the capability to withstand a sudden frost during the later rapid phase of growth and early reproductive development.

Resistance to freezing injury alters markedly during the life of a plant in step with changes in environmental temperature (Sutcliffe 1977). Since the temperatures, to start with, fall gradually and the photoperiod decreases as the season progresses from autumn to early winter, seedlings of winter-planted chickpeas have a possiblity of acquiring some degree of tolerance to moderate subzero temperature as has been shown by Herzog (1978) for faba beans. However, a more severe frost may lead to freezing and death of plant parts or the whole plant, even at this stage. Besides freezing injury, which is caused by subzero temperature, exposure to low temperatures (0°–5°C) may retard growth owing to factors such as desiccation, poor water absorption by plants, starvation due to prolonged exclusion of light by a covering of snow, chilling causing disturbances in cell metabolism and accumulation of harmful metabolites. Under lowland conditions the desiccation and starvation may not be important as soil temperatures are generally quite favorable for root activity (Harris 1979), and the snow cover is seldom present for long. Identification of psychrophilic genotypes that show little chilling injury and are able to achieve a high growth rate because of their low optimal temperature for early growth (Sutcliffe 1977) is therefore necessary for winter planting.

From the above it is clear that screening genotypes for an adequate level of winter tolerance is not straightforward. A simple but reliable technique is required, but as no such method presently exists the natural environment in the 1978–79 through 1980–81 cropping seasons was used. Preliminary screening was undertaken at various ICARDA lowland sites and at a high plateau site near Ankara, Turkey, in collaboration with the Turkish National Program. The results from these studies are presented.

Results and Discussion

Cold Tolerance during Winter

The two lowland sites used in 1978–79 were Tel Hadya (36°5′N, 36°55′E) at an altitude of 392 m in northern Syria, and Terbol (33°52′N, 36°00′E) at an

altitude of 923 m in the Beqa'a valley of Lebanon. The high plateau site was located at Hymana (39°50'N, 32°40'E) at an altitude of 1055 m in Turkey.

Evaluation at Tel Hadya

A total of 3000 kabuli accessions from the germplasm collection were planted in November 1978. Each accession was sown in an unreplicated 5-m row, with the rows spaced 60 cm apart. The local chickpea landrace in Syria (ILC 1929) was sown after every two test entries. Plant emergence was recorded before the onset of severe winter conditions in the third week of November, when the minimum air temperatures fell below zero (–1 to –2°C) on five consecutive nights. The lowest air temperatures during December 1978, January and February 1979 were, respectively, 1, –1, and 2.4°C and the monthly average minimum air temperatures were 5, 4 and 6°C, respectively.

At the end of the severe winter period, the lines were scored for cold tolerance in early February on a 1 to 3 scale, where 1 = free from cold injury; 2 = leaves of a few plants within each entry were partially affected showing epinasty and restriction of leaf expansion (these plants recovered completely afterwards); 3 = part or whole plant damaged with no possiblity of recovery. The results are presented in Tab. 1. Forty percent of the entries showed no cold injury, and 60% suffered a temporary effect of cold with no mortality.

Table 1
Screening chickpea lines for tolerance to cold at Tel Hadya, Syria, during 1978–79.

Rating	No. of entries	% of entries
1	1247	41.57
2	1753	58.43
3	0	0.00
Total	3000	100

Evaluation at Terbol

A total of 3182 kabuli accessions from the germplasm collection were sown in November 1978, in the same layout as at Tel Hadya. The local chickpea landrace (ILC 1930) was sown after every nine test entries. Plant emergence was recorded before the onset of the severe winter. The absolute minimum air temperatures during November and December 1978 and January, February and March 1979 were –6.8, –2.8, –4.0, –4.0, and 4.8°C, respectively. The mean monthly minimum air temperatures were 0.17, 3.08, 0.18, 1.63 and 2.26°C, respectively. The crop was covered with snow during December and January for several days.

At the end of the severe cold period, the lines were scored for cold tolerance on the 1 to 3 scale used at Tel Hadya. The results are shown in Tab. 2. Sixty-four percent of the entries showed no damage and 36% had temporary signs of cold injury. Throughout the winter the plants grew little, which may explain the lack of severe damage.

Table 2
Screening chickpea lines for tolerance to cold at Terbol, Lebanon, during 1978–79.

Rating	No. of entries	% of entries
1	2036	63.98
2	1146	36.92
3	0	0.00
Total	3182	100

Evaluation at Hymana

A total of 3158 kabuli accessions from germplasm collection were screened for cold tolerance at Hymana near Ankara during 1979–80. The material was sown in October 1979 in unreplicated 2-m rows, spaced 60 cm apart. The local chickpea landrace (ILC 1931) was sown after every nine test entries. Plant emergence was recorded before the onset of very severe winter conditions. The lowest air temperature during December 1979 and January, February and March 1980 were –9.0, –26.8, –12.3 and –13.8°C, respectively. The plants were covered with snow for 47 days.

At the end of the winter, the surviving plants of each entry were counted. Later, all entries were classified according to percentage survival using a 1–5 scale, where 1 = 100% (highly tolerant); 2 = 67–99% (tolerant); 3 = 34–66% (medium tolerance); 4 = 1–33% (susceptible); 5 = 0% plants (highly susceptible) survival.

The results are presented in Tab. 3. Four lines, namely, ILC 2636 (ex-India), ILC 410 (ex-Iran), ILC 2479 and ILC 2491 (ex-India) were highly tolerant to cold. Another two lines, ILC 2406 and ILC 2529 (ex-India), were tolerant and 23 lines had a rating of 3. The remaining lines were rated 4 or 5.

Discussion

There appears to be no published report on screening kabuli chickpeas to cold tolerance. Thus this screening is probably the first major effort in screening such a large number of kabuli accessions for cold tolerance at lowland and intermedi-

Table 3
Screening chickpea lines for tolerance to cold at Hymana, Turkey, during 1979–80.

Rating	No. of entries	% of entries
1	4	0.13
2	2	0.06
3	23	0.73
4	283	8.96
5	2846	90.12
Total	3158	100.00

ate elevations in the continental Mediterranean environment. The results of screening at Hymana have been published earlier (Singh et al. 1981).

The results of cold tolerance screening at Tel Hadya and Terbol, which represent a fairly wide range of thermal regimes for the lowland zone are very interesting. They reveal that the cold conditions of winter months in the lowland zone can be tolerated by the majority of the accessions, and therefore these cold conditions of the region are no barrier to the introduction of chickpeas as winter-planted crop.

At the intermediate elevations, i.e. towards the plateau zone, where the cold is more severe, the tolerance of most of the lines was rather poor. Only four lines could tolerate the severe winter conditions at Hymana, and even those showed death of some tissues and other symptoms of cold injury. However, the fact that there were lines, albeit few, that did survive indiates that chickpea cultivars could be developed for winter planting in Turkey, Iran, northern Iraq and similar areas of intermediate to high elevation in the region.

Of the 24 genotypes that showed 1,2 and 3 ratings in the evaluation at Hymana, 15 originated from India (Tab. 4). The tolerance to severe cold in lines originating from India is rather difficult to explain, as the winters in these chickpea growing areas are seldom severe. However, since desi types are predominately grown in India, there is a possibility that more sources of tolerance to cold might be available in desi germplasm. It would, therefore, be worthwhile to evaluate the desi germplasm maintained at ICRISAT for tolerance to cold.

The cold-tolerant lines were again sown at Hymana during 1980–81 season for confirmation of their tolerance. These lines are also being simultaneously used in the crossing program. Physiological studies on the mechanism of tolerance will be taken up in lines in which the tolerance is confirmed.

Table 4
Origin of lines having 1, 2 and 3 ratings for cold tolerance at Hymana, Turkey.

Rating	ILC Number	Origin	Rating	ILC Number	Origin
1	2636	India	3	187	USSR
	410	Iran		2487	India
	2479	India		3177	Turkey
	2491	India		3180	Turkey
2				3195	Unknown
	2406	Unknown		3204	Unknown
	2529	India		3226	Unknown
				1950	India
3	413	Iran		2486	India
	1878	India		2505	India
	2449	India		3072	India
	189	Bulgaria		3073	India
	191	USSR		2408	India
	193	USSR		2443	India
	606	Algeria		3253	Unknown
				3083	India

Studies on Tolerance to Late Frost

The need for tolerance to a sudden late frost for chickpeas grown in the lowland zone of the region during winter has been emphasized earlier. Again, little published information is availiable on this aspect. In North India, where chickpeas are planted in autumn, they often suffer severe damage from winter frost, if that coincides with the onset of the reproductive growth (Sharma et al. 1971).

Field screening for tolerance to late frost

It is difficult to plan a study for screening against sudden frost damage under field conditions, as its occurrence and magnitude are unpredictable. For example, Harris (1979) reported that frost may occur as late as the first week of April once in every 13 years in the ICARDA site at Tel Hadya. Fortunately the 1980–81 cropping season has proved to be one such season. On the night of April 1, 1981, the minimum air temperature dropped to –2.5°C. The crop at this stage was growing rapidly as the minimum air temperature up to this stage ranged from 3.5 to 10°C and the mean air temperature from 10.7 to 14.3°C. On April 2 the minimum temperature was again sub-zero (–2.2°C), and by April 3 the crop showed severe frost damage.

The occurrence of this frost was used to evaluate tolerance among the germplasm material planted in winter for seed increase, entries in spring-planted trials and new cultivars planted in a date of planting x variety trial. The winter-planted

germplasm was in the pre-flowering stage, whereas in the spring-sown trials the plants were still seedlings. The stage of crop growth in the date of planting trial varied from flowering to seedling, depending on the date of planting.

A 1–9 point scale was used for scoring the frost damage, where 1 = no visible damage (highly resistant); 3 = only a few leaves were killed causing negligible crop damage (resistant); 5 = part of the branches were killed causing some damage to the crop (tolerant); 7 = a large proportion of branches and a few plants were killed causing considerable damage (susceptible); 9 = all plants were killed causing total loss of yield (highly susceptible).

Results of the valuation of 2062 kabuli germplasm accessions at the preflowering stage and 314 accessions at the seedling stage are presented in Tab. 5. Three conclusions can be drawn. First, the crop at the seedling stage was more resistant to frost than at the preflowering stage; about 99% of the lines were resistant at seedling stage. Second, at the preflowering stage only one line was rated as highly resistant, 164 lines as resistant, 356 lines as tolerant and the remaining 1541 lines as susceptible. Third, no line was completely killed, but the severe late frost damage to 75% of the lines planted in winter, highlighted the need for incorporation of late frost tolerance, in addition to cold tolerance and ascochyta blight resistance in cultivars for winter planting.

Table 5
Screening chickpea lines for resistance to frost at Tel Hadya, Syria, 1980–81.

Frost rating	Pre-flowering stage		Seedling stage	
Scale	No. of entries	% of total	No. of entries	% of total
1	1	0.05	0	0.00
2	3	0.15	234	74.52
3	38	1.84	77	24.52
4	123	5.96	1	0.32
5	356	17.26	2	0.64
6	221	10.72	0	0.00
7	1320	64.01	0	0.00
8	0	0.00	0	0.00
9	0	0.00	0	0.00
Total	2062	100.00	314	100.00

The lines that were evaluated at both the seedling and pre-flowering stage, showed little similarity in the ratings to frost tolerance at these two stages. Lines rated 2 as seedlings, were rated anywhere between 3 to 7 at the pre-flowering

stage (Tab. 6). Of the five cultivars in the date of planting trial (Tab. 7), two showed no frost damage even at the flowering stage. One of these, namely, ILC 202, also has a high degree of resistance to aschochyta blight, the remaining three genotypes showed a reasonable level of tolerance to frost at the pre-flowering stage and possess tolerance to aschochyta blight.

Table 6
Frost reaction of a few lines identified as resistant at the pre-flowering and seedling stages.

	Frost reaction			Frost reaction	
Acc. No.	Seedling	Preflowering	Acc. No.	Seedling	Preflowering
ILC 3279	2	2	ILC 7	2	7
ILC 72	2	3	ILC 75	2	4
ILC 194	2	3	ILC 76	2	7
ILC 212	2	3	ILC 108	2	5
ILC 456	2	3	ILC 119	2	6
ILC 482	2	3	ILC 120	2	7
ILC 1246	2	3			

Table 7
Effect of date of planting on the frost tolerance of some chickpea genotypes. Evaluation made 5 days after occurrence of frost at Tel Hadya, 1980–81.

	Planting dates			
Stage of crop growth	Nov 19	Dec 21	Jan 23	Feb 22
at frost occurrence:	Flowering	Preflowering	Vegetative	Seedling
Genotypes				
ILC 482	6	3	3	1
ILC 484	6	3	3	1
ILC 262	1	1	1	1
ILC 190	6	3	3	1
ILC 202	1	1	1	1

Discussion

The observed reaction of chickpeas to sudden frost at various stages of ontogeny is consistent with that observed for other crops (Levitt 1969; Sutcliffe 1977; Herzog 1978). More rapid growth and advanced ontogenic development are associated with higher sensitivity to frost damage for which Levitt (1969) has

proposed a biochemical explanation involving the sulphydryl (–SH) groups of the proteins in the cell.

The study has helped in identification of a few lines that are resistant to this kind of stress, which is of importance in winter planting of chickpeas in the region. Fortunately several lines identified as frost resistant are also resistant to ascochyta blight. Some of these are ILC 3279, 72, 194, 202, 482 and 484. ILC 202 showed a high level of tolerance even at the flowering stage. It will be desirable to confirm the tolerance of these lines to late frost either under controlled environmental conditions or by growing at locations where frequency of late frost is higher.

Summary

For the success of winter planting, tolerance to cold winters during the early vegetative phase as well as tolerance to sudden late frosts are essential attributes of a chickpea genotype. With this objective in view, accessions of kabuli genotypes were evaluated against these two stresses under field conditions.

The evaluation at Tel Hadya (Syria) and Terbol (Lebanon) sites of ICARDA in the lowland region during 1978–79 revealed that most chickpea lines can tolerate the cold winter conditions of this region. However, evaluation at the intermediate elevation site at Hymana in the Anatolian Plateau (Turkey) showed that only a few lines were capable of tolerating the harsh winter conditions there. Six lines have been identified as tolerant, and they are being utilized in the hybridization program for the development of high-yielding, winter-hardy cultivars, for the plateau regions of Turkey and Iran.

The evaluation of the kabuli collection for late-season frost tolerance showed that there was no correlation between the tolerance rating at the preflowering and seedling stages. Evaluation at the reproductive phase seems to be more desirable. A large number of lines have been identified as frost resistant, but they will have to be reevaluated for confirmation.

The need for evaluation of more lines and an understanding of the bases for cold tolerance and late frost resistance has been emphasized.

References

HARRIS, H.C. 1979. Some aspects of the agroclimatology of West Asia and North Africa. *In* Food Legume Improvement and Development (Hawtin, G.C. and Chancellor, G.J. eds), ICARDA, Aleppo, Syria and IDRC, Ottawa, Canada.

HAWTIN, G.C. and SINGH, K.B. 1981. Prospects and potential of winter sowing of chickpeas in the Mediterranean region. This volume, pp.7–16.

HERZOG, H. 1978. Wachstumsverhalten und Kältetoleranz bei Ackerbohnen (*Vicia faba* L.) unter verschiedenen Testbedingungen. 2. Assimilationsleistung und ihre Veränderung nach Gefriertests. Zeitschrift f. Acker-u. Pflanzenbau, 147:111–120.

KASSAM, A.H. 1981. Climate, soil and land resources in North Africa and West Asia. pages 1–29 *in* Soil, Water and Nitrogen in Mediterranean-type Environments (Monteith, J. and Webb, C. eds.). Martinus Nijhoff Dr. W. Junk Publishers, The Hague.

LEVITT, J. 1969. Growth and survival of plants at extremes of temperature – a unified concept. Soc. Expt. Biol. Symp. 23:395–448.

SAXENA, M.C. 1979. Recent advances in chickpea agronomy. Pages 89–96 *in* Proceedings, International Workshop on Chickpea Improvement, Feb. 28–Mar 2, 1979, ICRISAT, Patancheru, A.P., India.

SHARMA, A.K., TEWARI, R.K. and TEWARI, A.S. 197: Study on the incidence of frost on gram (*Cicer arietinum* L.) Allahabad Farmer 45(4):407–408.

SINGH, K.B., MEYVECI, K., IZGIN, N. and TUWAFE, S. 1981. Screening kabuli chickpea for cold toloerance. International Chickpea Newsletter No. 4:11–12.

SMITH, R.C.G. and HARRIS, H.C. 1981. Environmental resources and restraints to agricultural production in a Mediterranean-type environment. Pages 31–57 in Soil, Water and Nitrogen in Mediterranean-type Environments (Monteith, J. and Webb, C. eds.). Martinus Nijhoff/Dr. W. Junk Publishers, The Hague.

SUTCLIFFE, J. 1977. Low temperature tolerance. Pages 40–48 in Plants and Temperature. Edward Arnold, London.

Discussion

S. Hanounik

Do you have any plans to improve frost tolerance of ILC 482 through crossing with say ILC 202 which according to your data was rated 1 at different stages of frost occurrence?

K.B. Singh

After identifying ILC 202 as frost tolerant, we have utilized this genotype in crossing with ILC 482 and other high-yielding lines. Our biggest dilemma at the moment is how to screen for frost tolerance in segregating generations especially in view of the uncertainty of occurrence of late frost. While selecting plants in segregating generations for other characters, hopefully, we may inadvertently select for frost tolerance. Once screening methods are devised, evaluation will be easy.

M. Kamal

Is it better to do screening for cold tolerance in a chickpea growing area where frost occurs more frequently?

K.B. Singh

Yes, that would provide more reliable information. But do we know such places? My request to the participants would be to let us know if there are places where late frost is of common occurrence and chickpeas can be grown.

We wish to utilize such places for screening chickpea germplasm for late frost tolerance.

D. Keatinge

Ensure that future cooperators in frost tolerance present air temperatures preceding the minimum temperature event to account for pre-conditoning effects!

M.C. Saxena

Your point is quite valid. In fact, in the paper these data have been qualitatively discussed.

G.C. Hawtin

We have heard about the danger of late frost at the early flowering stage. I can envisage a situation where early frosts, say in November or early December, can also be important, i.e. plant growth may be occurring with high day time temperature but sudden drops in temperature at night and frosts could be very damaging. Do we have any data on the probability of getting such early frosts?

K.B. Singh

We agree with your observations but unfortunately we do not have data on frost occurrence in early winter. Such information would be useful, not only from Syria but from throughout the region, where the crop is spring-sown with a possibility of introducing winter sowing.

H. Harris

The occurrence of frost in the early part of the season has not yet been examined, and we, therefore, have no information on the chance of frosts occurring during the seedling stage of growth of autumn-sown crops.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

The Impact of Winter-Sown Chickpeas on Insect Pests and their Management

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Recent research has shown that in and around Syria, winter-sown chickpea substantially outyields the spring-sown crops. It is expected that there will be a substantial adoption of this practice in farmers' fields in the near future.

Any substantial change in the sowing date of a crop that is already well established in a traditional cropping system can bring about some changes in pest incidence, not only on that crop but also on other crops in the system. Although it is probable that winter-sown chickpea will suffer no greater pest attack than the spring-sown, it is possible that the introduction of a winter-sown crop might provide an earlier buildup of pests that will then disperse to subsequent spring-sown crops including chickpea. Alternatively, a relatively unimportant insect might become important either on the winter or succeeding crop, and so cause problems for the farmers.

This possibility should be neither overestimated nor ignored. From our present knowledge it would appear likely that the yield benefits that will be gained from winter-sown chickpeas will greatly outweigh any consequent changes in pest problems. However, our knowledge of pests and their management, even on spring-sown chickpea, is inadequate and there is an urgent need to investigate in depth the present and potential pest problems, both on winter- and spring-sown crops. This paper is intended to briefly summarize the current state of our knowledge and speculation in this area and to suggest the needs for future research, with particular regard to the impact of large-scale cultivation of winter chickpea.

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Chickpea Pests and their Potential for Damage

The insect pests that have been recorded on chickpea crops in the eastern Mediterranean region are listed in Tao. 1. As for chickpeas grown in other areas of the world, the pest list is surprisingly short. Chickpea is relatively free from many potential pests, probably because of the very acid droplets exuded from the glandular hairs which cover these plants. By far the most important pests listed are the pod borers (*Heliothis* spp.) and the leaf miner (Hariri 1979).

Table 1
Insect pests reported on chickpea in the eastern Mediterranean region.

Insect pest	Family	Damage	Reference
LEPIDOPTERA:			
Heliothis armigera (HB.)	Noctuidae	Pod borer	1,2,3*,4
H. viriplaca (Hufn.)	Noctuidae	Pod borer	1
H. peltigera (Schiff)	Noctuidae	Pod borer	1
Marasmarcha echrenbergiana Zell	Pterophoridae	Leaf/Pod?	NR
Agrotis ypsilon (Hufn.)	Noctuidae	Leaf/Stem	4
A. segetum (Schiff)	Noctuidae	Leaf/Stem	1
Autographa gamma (L.0	Noctuidae	Leaf	1
Trichoplusia ni (Hb.)	Noctuidae	Leaf	1
DIPTERA:			
Liriomyza cicerina Rond.	Agromyzidae	Leaf miner	1
L. congesta (Beck).	Agromyzidae	Leaf miner	5
COLEOPTERA:			
Sitona crinitus Hbst.	Curculionidae	Leaf	1
HEMIPTERA:			
Acyrthosiphon pisum (Harr.	Aphididae	Sap feeder	1
Aphis craccivora Koch	Aphididae	Sap feeder	1

1 = Hariri (1979); 2 = Talhouk (1969); 3 = Moradeshaghi (1977–); 4 = Kawar (1979); 5 =Jaffari (1975)

NR =New record; ? = To be confirmed.

* = This report lists *H. obsoleta* which is considered to be a synonym of *H. armigera*.

There is little information available on the extent of losses caused by the insect pests. Kawar (1979) recorded about 6% pod damage by *Heliothis* in March- and April-sown crops in Lebanon, and later-sown crops had even less damage. There are reports of leaf miner being "important" in Syria (Hariri, 1979 and Kemkemian, 1979), in Turkey (Gentry 1965; Giray 1970) and in Spain, Israel and USSR (Kay 1979). However, an estimate of yield loss is only available from Tadzhikistan (USSR) where Koinov (1968) estimated the loss to range from 10–40%. In Spain, Cubero (1975) reported that yield loss estimates were inadequate, in spite of several years of study on leaf miner.

At ICARDA preliminary attempts have been made to quantify the yield losses caused by the pests, through observation and through pesticide trials on winter- and spring-sown crops. It was hoped to partition the losses caused by leaf miner and *Heliothis* spp. by differentially controlling these pests. Unfortunately, it was not possible to identify pesticides that would adequately control either pest and not affect the other. Also inter-plot effects, largely caused by the dispersal of the mobile pests, obscured any differences in these replicated, small plot trials. It was found that methidathion at 0.5 kg a.i./ha gave good control of both *Heliothis* spp. and leaf miner. However, the yields from treated and pesticide-free plots were disappointingly low and differences were not consistent (Tab. 2). The cultivar used was Syrian Local, which is susceptible to ascochyta blight. This disease was particularly damaging in the large, pesticide-protected, winter-sown block. These obviously affected the comparisons of yields. This data, however, indicate that factors other than pests may be the major determinants of yield and that the unprotected winter crop gave yields equal to, or better than, those obtained from the protected spring crop.

Pod damage by *Heliothis* spp. was greater in the pesticide-free winter crop as compared with the spring crop. *Heliothis* spp. are generally attracted to well grown crops and presumably the better crop growth in this limited unprotected area of winter crop was more attractive to the insect and so the damage was greater.

The leaf miner attack apparently starts in March-April in most years in the Aleppo area. Then, the winter-sown crop is well established with good growth, but the spring-sown crop is only in the seedling stage. In May 1980 there was a moderate attack of leaf miner across all plots of chickpea at the ICARDA Center (Tel Hadya), Aleppo, both on winter and spring sown. By this time, however, the wintersown crop was in the late podding stage and it is unlikely that the foliar damage by leaf miner would result in much yield loss, if any. Presumably such leaf miner attacks would be more damaging to the spring-sown crop which was in the early pod stage at that time.

The other insects listed in Tab. 1 were either not found or were relatively rare, during the 1980 observations, and were not important. However, while consider-

Table 2
Estimates of pod damage and grain yield in protected and unprotected winter- and spring-sown chickpeas (cv: Syrian Local), Tel Hadya, Syria, 1979–80.

	Expt.*	Winter crop		Spring crop	
		Protected	Unprotected	Protected	Unprotected
Pods/plant	1	11	10	7	6
	2	11**	15	6	4
% bored pods	1	0.4	4.0	2.0	2.7
	2	0.6	16.3	0.3	1.6
Grain yield	1	805	685	662	548
	2	749**	956	491	284

* 1 = four replicated small plots – three sprays of methidathion at 0.5 kg toxicant/ha each;
2 = Unreplicated large plots – soil application of carbofuran at planting followed by three sprays of methomyl (dose as above).
** = *Ascochyta* damaged.

ing the potential role of winter-sown chickpea in changing the incidence of insects, due attention must be given to all of these insects, some of which may become important.

The cutworms (*Agrotis* spp) feed voraciously on the foliage and the later instars can cut the stems, thus leading to plant mortality. *A. segetum* which is common in this region is known to attack both winter and spring crops and has been recorded as causing severe damage to chickpeas, maize and cotton. The polyphagous semiloopers (*Autographa gamma* and *Trichoplusia ni*) have caused damage to chickpeas and lentils in some years, particularly in the spring months. Plume moth (*Marasmarcha ehrenbergiana*) larvae on chickpea foliage were observed in the Aleppo area. This is the first record of this insect on this crop.

The aphids (*Aphis craccivora* and *Acyrthosiphon pisum*) are often found on chickpeas in this area, but they do not generally build up to damaging populations. However, they may cause substantial crop loss, by acting as vectors of stunt virus which has been recorded in this region. The weevils (*Sitona crinitus*) feed on the leaves of chickpea as well as on lentil, vetch and lucerne, and cause damage to young plants (Hariri 1979).

Seasonality and Carryover

The greatest limitation in foreseeing the potential pest problems of winter-sown chickpea is the inadequate knowledge about the survival, buildup and carryover

of the major and minor pests in this area. A summary of the available knowledge is given in Tab. 3.

On spring-sown chickpea the major pests, *Heliothis* spp. and leaf miner, first appear in low numbers in April, during the seedling stage. They may then build up to damaging populations in May-June during the podding stage. This was the case in 1980, but that year was unusual in having a relatively cool spring. In such a year the winter-sown chickpea will merely act as an alternative to the spring-sown chickpea as a host for the pests from April to June. The cold winter through which the early-sown chickpea grows, albeit slowly, would preclude the early buildup of pests. A similar situation is apparent in northern India where winter-sown chickpea has a very low infestation of almost all pests until the warmer weather arrives.

Table 3
Seasonal incidence and carryover potential of some of the common pests on chickpea in the eastern Mediterranean region

	Known period of occurrence on 'spring' chickpea	Generations per year (duration from egg to adult)	Carryover potential	
			Diapause	Other host plants
POD BORERS: *Heliothis armigera*	Apr–June	Many (4–8 weeks)	Yes	Yes
LEAF MINERS: *Liriomyza cicerina*	Apr–June	2–4 (2–4 weeks)	Not clear	Yes
CUTWORMS: *Agrotis* spp.	Spring season	At least 6 (5–10 weeks)	Yes	Yes
APHIDS: *Acyrthosiphon pisum* *Aphis craccivora*	Apr–June	Many (2–3 weeks)	Not clear	Yes
LEAF WEEVILS: *Sitona crinitus*	Nov–Dec/ (early) Apr	One	Yes	Yes

There is an obvious danger from the *Heliothis* spp. in Syria in years when a mild winter or an early spring allows the moths to emerge in February-March, as recorded by Hariri (1979). Most plants are attractive to *Heliothis* spp. egg-laying only during the flowering and fruiting period and there are unlikely to be many such hosts in February-March in the Aleppo area. However, chickpea is an exception, for it is attractive to *Heliothis* spp. egg-laying moths from the seedling stage and so could act as a host for an early buildup of these pests.

We do not yet know whether most *Heliothis* spp. infestations in Syria originate from diapausing pupae which survive the winter within the country (diapause has been reported by Talhouk 1969), or from immigrants from southern countries, or from the coast, where the winter is not severe enough to prevent this pest from feeding and breeding through the year. If *Heliothis* spp. have previously failed to establish in Syria in February-March in warm years because of the lack of a suitable host at that time, the winter-sown chickpea could fill this niche. This might allow an extra generation of this pest and so multiply the subsequent attack on spring-sown chickpea and on other crops such as cotton.

If the major source of the *Heliothis* spp. moths is from diapausing pupae, the lack of an early host will give selective advantage to late emergents, for early emergence would be suicidal. The availability of an early host would give selective advantage to the early emergents and the pattern of emergence from diapause could rapidly change to take advantage of this new opportunity.

Similarly, little is known about the carryover of the leaf miner from season to season. In 1980, it was first noticed in early April and at that time the spring-sown chickpea was already available as a host. So, here, as with *Heliothis*, the winter-sown crop appeared to give no earlier buildup opportunity for this pest. It is suspected that overwintering in the pupal stage may be one means of carryover. However, if there is an early emergence from these puparia in February or March, or an immigration from other areas at that time, the winter-sown chickpeas might be hit by one or two extra generations. Also, this may greatly enhance the attack on the spring crops in the region.

Similar possibilities obviously exist for an earlier establishment of most or all of the other insects that have been recorded on this crop in this region. There is also a small possibility that other insects that have not yet been recorded on the crop will find an opportunity to build up on the winter-sown crop.

Possible Effects of Differing Proportions of Winter- and Spring-Sown Crops

Up to now the vast majority of the chickpea crop grown in the area has been spring sown and the experimental sowings of winter crop can hae no effect on this. On Tel Hadya farm, however, one-third or more of the chickpeas in 1980 were winter sown and there was no obvious detriment to the spring-sown crop. If, as expected, the advantages of winter-sown chickpea soon become apparent to several farmers, then a substantial proportion of the Syrian crop could be winter sown within the next few years. During the transitional stage the threat to the spring-sown chickpea may well increase. If all the crop is eventually winter sown then there will be no spring-sown crop to threaten. At that stage, the *L. cicerina* leaf miner problem will be of little or no extra concern for it is not known to

attack any other important crop plants; it is suspected that it will cause little yield loss on the well grown winter-sown chickpea. The polyphagous pests, including *Heliothis armigera* will feed on other crops including cotton and maize, and there is a faint possibility of increased pest problems on such crops.

Research Requirements for Pest Management on Winter-Sown Chickpeas

The spring-sown crop has not been very high yielding, and pesticide use on the crop has not given substantial yield increases. The leaf miner damage often looks serious but there is no evidence that it has caused substantial yield loss. In some areas and years the *Heliothis* spp. attacks can damage a substantial proportion of pods and several farmers apply "cotton dust" (DDT/BHC) to control such attacks, particularly in sourthern Syria.

If the winter sowing proves successful, then yields will be increased and the losses due to pests may, at the worst, increase only proportionately. Pesticide use may be the simplest and cheapest means of reducing such losses. There is a need to improve upon the present practice of dusting with the polluting chlorinated hydrocarbons. Heavy doses of methidathion are effective against the chickpea pests but such treatment may be too costly. Pesticide experimentation, with emphasis upon cost: benefit ratios and upon safety for man and his environment, is of obvious priority.

Search for alternative means of pest management should not be neglected. Host-plant resistance has already proved to be a promising means of reducing the *Ascochyta* threat to the winter-sown crop. It may be possible to reduce the insect pest attacks by a similar means. Preliminary data indicate that there are differences in susceptibility to pests. It is unlikely that a high level of resistance to the pest complex or to individual pests will be rapidly or easily found or exploited. However, the cost of a modest screening program for resistance is infinitesimal when compared with the potential benefits. Monitoring/screening of breeding materials is essential, at least to ensure that more susceptible materials do not emerge from breeding programs. There is always a danger of this happening wherever much, or all, of the breeding and testing is done under a pesticide umbrella.

It is possible to change the susceptibility of chickpea crops to pests by changing the agronomic conditions. For example, at ICRISAT it has been found that greater populations of *Heliothis armigera* larvae per unit area are associated with increased plant density but with little effect on the percentage of pods damaged or yield. A winter-sown trials at ICARDA in the 1979–80 season showed that an increase in plant density from 33 to 50 plants/m^2 gave substantial increases in yield for most cultivars tested. This work should be followed with

large plot comparisons of plant densities under protected and pesticide-free conditions. It has been reported that in Bulgaria, deep plowing gives considerable reduction of the leaf miner populations (van der Maesen 1972). The effects of this and other agronomic practices on pest-caused losses also need to be studied at ICARDA.

The natural enemies can play an important role in limting pest populations. Indiscriminate pesticide use can destroy the beneficial fauna and eventually lead to greater pest problems. It may be possible to augment the natural control elements and some research in this area might be profitable.

The first essential, however, would be to obtain basic information on the biology and ecology of the pests and their natural enemies in the present system in this region. A cursory scan of literature has revealed a surprising lack of basic information on the major chickpea pests. Until such information is available it is not possible to plan for adequate pest management on this crop. The lack of knowledge of the basic biology and ecology of the pests has also forced speculations about the effect of winter sowing of chickpeas. A better knowledge would have allowed model predictions for such a change.

It is necessary to accumulate data that will allow us measurements of the impact of winter-sown crops on the insect pest populations. If there is an unusually heavy attack of leaf miner on spring-sown chickpea or of *Heliothis* spp. on any of the spring or summer crops in the next few years, there will be no shortage of people who will attribute the blame to the winter-sown chickpea development. It is important to accumulate facts and knowledge that will allow scientists to defend this development against ill-informed criticism.

References

CUBERO, J.I. 1975. The research on the chickpea (*Cicer arietinum*) in Spain. Pages 103–106 *in* Proceedings of the international Workshop on Grain Legumes, ICRISAT, 13–16 Jan., 1975, Hyderabad, A.P., India.

GENTRY, J.W. 1965. Crop Insects of North East Africe – South West Asia. Agriculture Handbook No. 273: USDA, ARS. Pub. 106 pp.

GIRAY, H. 1970. (Investigations on the morphological characters, brief biology and type of damage of *Liriomyza cicerina* Rond. (Diptera: Agromyzidae) (in Turkish) Ege Univ. Ziraat. Fak. Izmir, Turkey, No. 171, 34 pp.

HARIRI, G. 1979. Insect pests of chickpea and lentils in the countries of the eastern Mediterranean: A review. Pages 120–123 *in* Food Legume Improvement and Development (Hawtin G.C. and Chancellor, G.J. eds.), ICARDA-IDRC Publication. 216 pp.

JAFFARI, J. 1975. The status of chickpea (*Cicer arietinum*) in Iran. Pages 103–106 *in* Proc. Intntl. Workshop on Grain Legumes, 13–16 Jan. 1975, Hyderabad, A.P., India.

KAWAR, N.S. 1979. Insect pests of food legumes in the Middle East. Pages 112–119 *in* Food Legume Improvement and Development (Hawtin, G.C. and Chancellor, G.J. eds.), ICARDA-IDRC Publication. 216 pp.

KAY, D.E. 1979. Food Legumes – Crop and Product Digest No. 3. Tropical Products Institute, London, 435 pp.

KEMKEMIAN, A.A. 1979. Some insect pests of leguminous crops in Syria. Pages 124–125 *in* Food Legume Improvement and Development (Hawtin, G.C. and Chancellor, G.J. eds.), ICARDA-IDRC Publication. 216 pp.

KOINOV, G.M. 1968. Nagut, *Cicer arietinum*. Sofia. p. 191.

MORADESHAGHI, M.J. 1977. Pests of legume crops. Pages 87–92 *in* Food Legume Crops Improvement and Production, FAO Plant Production and Protection Paper 9, Rome 1977, 248 pp.

TALHOUK, A.M.S. 1969. Insects and mites injurious to crops in the Middle Eastern countries. Verlag Paul Parey, Hamburg and Berlin.

VAN DER MAESEN, L.J.G. 1972. *Cicer L.* – A monograph of the genus with special reference to the chickpea (*Cicer arietinum*), its ecology and cultivation. H. Veenman and Zonen, N.V. Wageningen. 342 pp.

Discussion

S. Hanounik

Would you please comment on the relationships between leaf miner and viral diseases of chickpeas? There have been some reports on such relation in other crops.

S. Sithanantham

As for disease transmission, the known groups are only aphids *Acyrthosiphon pisum* and *Aphis craccivora*. As for *Liriomyza*, there is no reported association with diseases, except for a casual mention of possible association with *Ascochyta rabiei*, but this could not be confirmed.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chichkpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Socioeconomic Implications of Winter Chickpea Production

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Seldom has a technological change been developed that so clearly improves the production potential of a specific crop. Chickpeas that are resistant to ascochyta blight and thus can be planted in November rather than February or March have shown very large yield increases indeed. This potential has been clearly illustrated in several of the previous papers.

It is unlikely the increased costs or other socioeconomic phenomena would detract from the attractivness of such a large productivity gain. Nevertheless, we now need to test this new technique under farm conditions, i.e., on farmers' fields with the farmer in control of the production process. These tests will allow us to confirm or refute the hypothesis that the new cultivars and new planting date are economically beneficial to the producers. They will also allow us to measure the economic gain.

Partial budgeting is the proper economic tool to use to test this hypothesis. Budgets are constructed that include only the changes in costs of production (thus the use of the word partial) that accrue with the introduction of the new technique. Then, the two partial budgets, one for the old method and one for the new, are compared and economic gains can be calculated.

Such budgets were hypothetically constructed for Syria to show the major areas where increases in cost will occur if the new technique is adopted. The actual partial budget for the winter-planted chickpeas must wait until these costs can be measured under farmers' conditions. Yet, the hypothetical case gives us some useful insights.

First, due to the size of the yield increase, almost all production costs increase. For example, harvesting and marketing costs increase since a higher yield requires more labor for harvesting and threshing the crop, more bags are needed and the transport of the increased production is greater. However, these increases will, most certainly, not be high enough to affect greatly the attractiveness of using the new cultivars planted at a different date.

On the other hand, two items that could increase costs significantly and must be watched very closely are planting costs and weed control. Currently, chickpeas are planted in February or March which are slack times in the agricultural labor calendar and consequently labor is relatively inexpensive. If we recommend that chickpeas be planted in November or early December this activity will compete with the land preparation of wheat, barley, lentils and vetch. At current wage rates in Syria, wages in November are 60% higher than wages in February. Thus, we have identified one potential bottleneck in the diffusion of this new technology.

Secondly, the current planting date and method of land preparation require little weed control. Some farmers indicated that they do some handweeding later in the spring, but do not use herbicides. ICARDA off-site experimentation has shown that weed control will need to accompany winter planting or weed competition will greatly reduce yields. Therefore, we need to develop effective weed control and determine its cost. Also we must assure that farmers realize that weed control will be required if the planting date is advanced.

Personally, I am optimistic and feel that the yield increases from new cultivars planted in November are significant enough to pay for the increased costs and yet produce attractive increases in net benefits.

There remains a very important matter outside of the immediate concern of production scientists which deserves mention here. Chickpea is a relatively minor crop in the ICARDA region when compared with wheat, for example. An increase in area allocated to chickpea production could greatly increase the total production and the supply of the crop in a country, or even in the region. Since chickpeas are a relatively minor input into the diets of people in the region, it is most probable that the demand for chickpeas by consumers in the region is inelastic, i.e., changes in consumption patterns will not be affected very much by changes in prices. These two characteristics of the chickpea market could result in rather drastic reductions in market prices if total production gains are forthcoming. This price decrease could "wipe out" the advantages of increased productivity for an individual farmer.

ICARDA is aware of this problem and is actively engaged in a study that is looking at supply and demand relationships and price determination of food legumes in the region. This is an important macro-economic issue that concerns government policy with respect to price setting, imports and exports and other forms of market intervention. If this situation can be foreseen, then negative effects can be forestalled and possibly alleviated altogether.

This conference is primarily technical in focus and I appreciate the opportunity to stress socioeconomic issues that affect and are affected by the potential for large increases in chickpea production in the Middle East. It is appropriate to include these issues in such a conference since it is the people who will be affected by research – people whose livelihoods we aim to improve. Winter

planting of chickpeas apparently offers tremendous potential for such improvement. The next step, i.e. on farm, farmer-managed trials should be taken quickly.

Discussion

M.C. Saxena
I would like to know the basis of your taking a yield level of 1300 kg/ha for farmer's yield in your partial budgeting.

D. Nygaard
Purely hypothetical to show you the value of partial budgeting. You could have a case where yield increases are more than offset by increased costs and the farmer would not switch to the new technique.

M.C. Saxena
Much of the weeds in the winter crops are used by small farmers for animal fed. Will this not, therefore, have compensatory effect in terms of cost of production of winter chickpea?

D. Nygaard
In Syria this is not a big problem because farmers keep their fields very clean during the winter months before they plant chickpeas. It may be more important in a country like Tunisia.

H. Harris
Do you have any estimate of the opportunity cost of reduced winter grazing on chickpea land which might result from winter sowings?

D. Nygaard
No numbers but it is a valid point. Fields in Syria are kept relatively weed free so this is not such an important issue as it may be in other countries, for example, Tunisia.

G.C. Hawtin
It may be possible to graze the winter crop and still get a yield advantage over the spring crop. This needs to be looked into further. Farmers in zone 2 are generally poorer and have a limited range of crop to choose from. In zone 1, chickpeas are just one of many alternatives. Over the past few years chickpeas have been spreading into drier areas anyway as a result of the high prices. Would it not be better to concentrate on zone 2, rather than zone 1 in considering winter chickpeas?

M.V. Reddy

It looks as if the cost of weeding in winter chickpeas is higher that the spring chickpeas. But the indirect benefits of weeding on soil fertility and lowering the weed population in due course of time should not be undermined. Competition for labor and implements between winter chickpeas and cereals may be only of a temporary nature. With increased returns from winter chickpeas and more mechanization, the problem may become less important and may not stand in the way of adoption of the improved technology.

D. Nygaard

I agree.

P. Cooper

If farmers keep their fields clean during winter by cultivation prior to planting spring chickpea, then in your partial budget you must allow for the fact that in winter planting they will not have this cost which should affect the increased weeding costs which you envisage.

D. Nygaard

Yes, a good point.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Fourth Session: Country Reports

Status of Chickpea in the ICARDA Region

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A joint contribution from ICARDA and ICRISAT Centers.

The center of origin of chickpea was suggested by de Condolle (1882) to lie between Greece and the Himalayas and between Krim and Ethiopia. Vavilov (1926) considered Hindustan and the Mediterranean region as the centers of origin. The range of the area where the possible center of origin of chickpea might lie was much narrowed down by van der Maesen (1972) who suggested that this species originated in southern Caucasus and northern Persia. More recently, Ladzinsky and Adler (1976) produced evidence in favor of south-eastern Turkey to be the center or origin and it is believed that from there this species spread at an early date to the countries in the Mediterranean region and the Indian subcontinent. Introduction to tropical Africa, Latin America, North America and Australia seems to have occurred more recently.

Thus, from the point of view of origin and spread of chickpeas, ICARDA region is of great significance.

Production

The average world production of chickpeas stands at 6.75 million metric tonnes (mt) for the period 1976–80 (Tab. 1). When compared with the corresponding values for 1948–52 (5.39 million mt), this amounts to an increase of 25.3%. Most of this increase has come from increased productivity as the increase in area has been very small.

ICARDA region accounts for about 15% of total area and about 13% of total production of chickpeas in the world (Tab. 1). Amongst the various food legumes grown in ICARDA region, chickpeas rank first (Hamawi, 1979). They accounted for 30.1% of total food legume production in the region during the period 1971-75. They are followed by faba beans (23.1%), lentils (11.8%), and dry beans

Table 1
Average area (in 1000 ha), production (in 1000 metric tonne), and yield (in 100 kg/ha) of chickpea in world, ICARDA region, and major producing countries from 1948–52 to 1976–80.

Country	1948–54			1961–65			1966–70			1971–75			1976–80		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
World	10187	5385	5.3	11839	7029	5.9	10247	6210	6.1	10140	6267	6.2	10263	6745	8.6
ICARDA region	1375	853	6.2	1634	928	5.7	1489	877	5.9	1456	917	6.3	1558	948	6.1
Algeria	24	11	4.5	21	10	4.7	30	15	4.8	28	12	4.5	39	21	5.6
Egypt							4	6	1.9	3	6	17.4	5	9	16.9
Libya										1		5.4			11.8
Morocco	81	39	4.8	136	65	4.8	116	77	6.9	116	83	6.9	67	42	6.1
Sudan	3	3	9.8	2	2	7.1	21	2	8.8	2	2	10.1		3	9.3
Tunisia	16	6	3.6	21	8	3.8	25	10	3.92	27	17	6.2	38	23	5.7
Cyprus										1		4.0	1	1	6.2
Iran	60	43	7.2	90	45	5.0	98	49	5.0	54	37	6.8	37	41	11.2
Iraq	3	2	6.0	5	3	6.2	5	4	7.1	8	4	5.7	14	9	5.8
Jordan	4.	2	5.4	6	4	6.7	3	2	5.4	7	3	5.9	2	1	3.6
Lebanon	2	2	9.6	1	1	8.8	3	2	7.1	3	2	6.5	1	2	18.4
Pakistan	1073	658	6.1	1225	675	5.5	1073	572	5.4	998	543	5.4	1123	550	4.9
Syria	29	16	5.5	41	26	6.4	42	36	8.1	55	33	6.4	57	35	6.6
Turkey	80	81	10.2	86	89	10.3	88	102	11.6	153	175	11.7	174	211	12.0
Others:															
Ethiopia	261	154	5.9	272	165	6.0	280	173	6.2	301	218	7.2	157	95	6.1
Mexico	125	92	7.3	134	118	8.8	181.6	144.4	7.96	230	202	9.5	183	226	11.7
Burma	87	31	3.5	117	56	4.8	109	62	5.6	154	71	4.6	141	82	5.80
India	7763	3989	5.1	9257	5537	6.0	7622	4731	6.1	7549	4599	6.1	7835	5772	6.6
Spain	354	141	4.0	237	124	5.2	199.6	126.4	6.32	143	77.0	5.4	105	62	5.9

Source: FAO Production Yearbook.

(9.7%). The major chickpea producing countries in the region are Pakistan, Turkey, Morocco, Iran and Syria.

Although in terms of production, chickpeas are the most important of the food legumes grown in the region, their productivity is amongst the lowest. In fact, whereas the productivity on the world basis has shown an increase in the period 1949–52 to 1976–80, it has shown a small decline (by about 1.6%) in the ICARDA region and the increase of about 11.1% in production over this period has come from an increase in area. The countries in the ICARDA region where production has increased are Turkey, Syria, Tunisia, Algeria, Iraq and Egypt. The countries registering a decrease in production are Pakistan, Iran and Jordan.

The increase in production of chickpeas in the region, which as mentioned earlier has all come from increased area, has not been able to keep pace with the increase in the population in the last 25 years, thus resulting in reduced per caput availability. Prices have risen, thus making this important legume out of reach for some of the lower income groups. Need for an increase in the productivity of chickpeas is therefore urgent.

Use

Chickpeas are used in a variety of ways. Major usage in the Indian subcontinent is in the form of 'dhal'. Chickpea flour is used for making sweets and snacks. One of the major chickpea preparations in parts of West Asia is 'Hommos-Bi-Tahineh'. Roasted chickpeas are also widely used as snacks. In North Africa and Spain, seeds are soaked overnight, boiled for an hour and sold in the market. Green seeds are eaten raw or cooked. Dry stems and seed hull are used as animal feed. Quality characters desired for different preparations are not well documented and therefore there is a need for the survey of the region for consumer preference and usage of chickpeas. Such information could be helpful in varietal improvement programs.

Trade

Although relatively insignificant in the world trade of food grain, both export and import of chickpeas have increased substantially in the 1970s. During 1971, 106,735 mt at a value of US$ 23 million were exported. The export went up to 167,069 mt at a value of US$ 123 million in 1980 (Tab. 2a). Major exporting countries of the world are: Mexico, Turkey, Spain, Morocco, Chile, Ethiopia and Tunisia. Likewise, import of chickpeas during 1971 was 70,265 mt at a value of US$ 16 million which rose to 147,335 mt at a value of US$ 123 million during 1980 (Tab. 2b). Major importing countries are: Spain, Algeria, USA, Jordan,

Table 2a
Export of chickpeas by some major countries during 1971–1980.

Country	1971 MT	1971 1000 $	1972 MT	1972 1000 $	1973 MT	1973 1000 $	1974 MT	1974 1000 $	1975 MT	1975 1000 $
World	106735	23317	105824	25832	149626	48827	122849	42841	111004	37892
Ethiopia	17565	2446	10654	1292	8112	1712	8182	2677	945	252
Morocco	30737	5154	3665	1149	19211	6435	20967	7070	22586	7327
Tunisia	1099	364	2407	865	1038	406	93	41	1521	677
Mexico	12304	2865	33164	8200	56813	21738	43625	19047	40617	17016
Chile	867	1255	165	66	332	143	120	58	573	532
Turkey	16874	5282	26299	7673	51071	14704	30610	8594	20488	5824
Spain	65	16	524	174	292	112	2256	931	146	92

1976 MT	1976 1000 $	1977 MT	1977 1000 $	1978 MT	1978 1000 $	1979 MT	1979 1000 $	1980 MT	1980 1000 $
93642	34507	127718	66066	153854	98792	174528	141474	167069	123831
332	82	30,882	9616	11612	4514	758	79	900	200
28163	10041	7536	4061	16436	12357	8984	6910	6726	3649
4878	1614	10211	5455	797	805	1499	1425	378	405
28450	11478	46522	27290	94151	56290	103246	85723	84080	61207
395	300	1209	790	1191	1937	5000	4000	1500	1300
24280	8455	25434	15612	20635	16546	45352	35942	55030	45293
249	158	473	416	2622	2079	5304	4168	13994	8991

Source: FAO 1981.

Table 2b
Import of chickpeas by some major countries during 1971–1980.

Country	1971		1972		1973		1974		1975	
	MT	1000 $	MT	1000 $	MT	1000 $	MT	1000 $	[illegible]	1000 $
World	70265	16255	89836	24639	93165	32810	69257	27583	72377	30542
Algeria			5253	1966	12469	4219	2164	762	11629	3998
U.S.A.	3699	1111	4192	1209	3912	1383	6217	2328	4551	1867
India	858	76	99	9	1355	179	384	67	255	51
Iraq	2158	371	2815	567	2468	807	10685	3372	6017	2215
Jordan	3683	621	2251	585	2755	1015	2394	799	1589	496
Saudi Arabia	1783	310	1888	416	2049	587	2967	911	2183	500
Spain	27357	8104	30045	10648	37632	13769	24745	11654	30375	14868

	1976		1977		1978		1979		1980	
	MT	1000 $	MT	1000 $	MT	1000 $	MT	1000 $	MT	1000 $
World	74385	35550	79894	53777	98663	77405	135959	114549	147335	123425
	13952	4989	10176	8226	8924	9286	43073	41488	43000	48000
	3705	1841	11298	6681	10775	7540	10468	8403	12769	9627
	201	24	1367	100	3018	667	3000	670	3000	670
	2994	1397	2000	1000	2000	1100	2000	1200	2000	1400
	890	276	1179	741	2313	1955	7768	6021	7800	7000
	3142	1013	1785	1075	2028	1536	3155	2257	2600	2206
	31928	16949	28538	23262	55874	43698	46986	41484	46241	36733

Source: FAO 1981.

India, Saudi Arabia, Venezuela and Iraq. Unfortunately, production lags far behind the demand.

Production Constraints

The major constraints to production are: (i) inherently low yield potential of landraces and local cultivars, (ii) lack of stability in production, mainly due to susceptibility to diseases, insect pests and environmental stress, (iii) lack of information on appropriate agronomy and/or lack of inputs, (iv) lack of mechanization of production practices and (v) inadequate research support.

In the major parts of West Asia and North Africa, the crop is sown in the end of the rainy winter on conserved moisture and thus made to complete its reproductive growth during the period of increasing heat and soil moisture stress. The practice of spring sowing seems to stem from the need to avoid the damage from ascochyta blight and perhaps cold, both of which pose a serious threat to chickpea crops when sown in winter. Ascochyta blight was first reported from the region in 1921 (Gonzalez 1921), but it must have existed for a longer period before being reported. Since chemical control does not seem to be conomical, development of Ascochyta-tolerant lines with adequate resistance to cold is a prerequisite to realize high yield potential of winter-sown crops. ICARDA has made significant progress towards this objective.

ICARDA's Role in Increasing Chickpea Production

ICARDA has assembled over 3500 kabuli germplasm accessions from all over the world. Evaluation of these for 27 characters revealed wide genetic diversity for morphological and economic traits and stress conditions. The information and material is available to scientists working in national programs for their use in breeding programs.

For the past 4 years, ICARDA has concentrated on the development of genetic stocks and cultivars for use by national programs. Breeding lines which will meet the requirements of national programs for spring and/or winter sowing, and for mechanical harvesting have been developed. In addition, material has been generated with seed size ranging from small to large to fulfill consumer preference in different countries.

Efforts have been made to develop, and help national programs in developing, improved production technology, covering herbicidal control of weeds, fertilizer and *Rhizobium* inoculation needs, optimum sowing date and plant geometry, crop rotation, integrated control of diseases and pests, etc.

One of the major aims of the program is to assist the national programs in

improving their scientific capability. Their scientific and technical staff are encouraged to visit the ICARDA Center for varying periods, ranging from a few days to 6 months, for exchange of ideas, material or for formal training. The program often organizes conferences and workshops with a view to provide an opportunity for fellow scientists from the world over to meet and discuss latest information on the subject. Proceedings are published and widely distributed. Also literature on different subjects is compiled and made available to interested persons.

Perhaps the biggest achievement in the chickpea improvement is the advancement of sowing date from spring to winter in the Mediterranean region. Doubling of yield has been observed by this single change. In order to make this feasible, ascochyta blight resistant and cold-tolerant lines are needed. Such lines have been identified from the germplasm collection and also developed through hybridization and are being made available to the national programs through international nurseries. Also, the associated technology has been worked out which aids further in improving the yield. Countries in the ICARDA region which do not practice winter sowing have an excellent opportunity to increase their production substantially by adopting this practice.

REFERENCES

de CADOLLE, A. 1882 L'origine des plantes cultivées. Paris. pp. 258.

GONZALEZ FRAGOSO, R. 1921. New or little-known Sphaeropsidales of the Spanish Fungus flora (in Spanish). Ascochyta Española para el Progreso de las Cienciias. Congreso de Oporto, VI. Cicencias Naturales: 35-37.

HAMAWI, F.M. 1979. Food legume production: the contribution of West Asia and North Africa to the world situation. *In* Food Legume Improvement and Development. IDRC Publication. 15-22.

LADIZINSKY, G. and ADLER, A. 1976. The origin of chickpea, *Cicer arietinum* L. Euphytica 25:211-217.

VAN DER MAESEN, L.J.G. 1972. *Cicer* L., a monograph of the genus, with special reference to the chickpea (*Cicer arietinum* L.), its ecology and cultivation. Commun. Agric. Univ. Wageningen 72-10, pp. 342.

VAVILOV, N.I. 1926. Studies on the origin of cultivated plants (in Russian). Leningrad:129-238.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4-7 May 1981, Aleppo, Syria

Chickpea Production in Syria

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Chickpea is the third most important food crop after wheat and faba bean as food in Syria. Table 1 shows the area, production and yield in 11 provinces in Syria. The planted area is about 0.87% of the total hectarage (5.8 million ha) of rainfed cultivated land. This area equals 0.4% of the total hectarage (11.853 million ha) of chickpea grown throughout the world, and equals 12% of the total hectarage (411,000 ha) in the Arab world. Chickpea production is about 35,670 tonnes. While most of this is consumed in Syria, about 5,000 tonnes is exported to other countries. Export income totals approximately US$2.5 million per year.

Chickpea Use in Syria

The seeds may be eaten roasted or raw (Malianeh). The dried seeds may be eaten after they are soaked, boiled and salted (Baleeleh), or after they are soaked, boiled, mashed and mixed with olive oil and lemon (Musabbaha). The dried seeds may also be eaten after they are soaked and boiled. The seeds are then mashed with parsley, tomato and yoghurt. Oil is then added as a dressing (Hommos Moudames). Or, the soaked and boiled seeds are mashed with peppers, and then deep fried (Falafel). The dried seeds may be eaten after they are soaked, salted and roasted (Homos Mashwi), or they may also be eaten as a sweet after being soaked, roasted and sugar-coated (Mlabes ala kedameh). The chickpea flour is used in the making of kaak dough (hard type of cake).

Chickpeas can also be made into a hot drink similar to coffee. They are roasted, crushed and then mixed with hot water and sugar. Chickpea seed has been used in the past as a primary medical treatment for nervous disorders.

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Table 1
Chickpea area (ha), production (t) and mean yield (kg/ha) in 11 Syrian provinces, 1976–78.

Province	1976			1977			1978			Mean (1976–1978)		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Dar'a	30601	20909	683	19425	11347	548	20587	18498	899	23537	16918	718
Sweida	15145	13847	913	5563	1408	269	7336	1168	159	9348	5474	585
Aleppo	4598	4317	939	2868	2802	969	4269	3318	777	3911	3479	889
Quneitra	3935	2361	600	2679	1605	586	1605	482	300	2740	1482	541
Damascus	3523	1912	536	3568	1912	536	4771	2754	577	3954	2193	544
Haska	2423	544	224	106	96	906	120	120	1000	833	253	286
Tartous	2302	1903	897	2332	2118	901	2630	1502	571	2421	1841	760
Idlib	1800	2012	1118	1993	1932	969	2053	1367	666	1948	1770	908
Homs	1504	1177	783	553	314	588	804	683	850	923	724	785
Hama	1132	1089	962	1480	942	632	1561	734	470	1391	921	662
Lattaqieh				468	332	709	392	307	783	430	319	743

Chickpea Cultivation

In Syria most of the chickpea crop is rainfed except for a small irrigated area (0.5% of the total).

Chickpea is planted in the spring from 15 February to 15 March, in two separate rotations. The first is a three-crop rotation (chickpea-wheat-fallow) which is employed throughout most of the semi-fertile areas, especially in the Hauran. The second is a two-crop rotation (chickpea-wheat) which is used mainly in the more fertile areas such as Homs and Hama as well as a small area in Hauran, Aleppo and Idlib.

Chickpea planting is semi-mechanized; the land is plowed several times by tractor in the summer after the harvest of cereal crops. The second plowing is done one month before planting date. The chickpea seeds are usually sown by hand (broadcasting), and are then covered with soil by an animal- or machine-drawn cultivator.

Fertilization is usually done directly before planting using 48% triple superphosphate at 100 kg/ha. The seeds are planted at a rate of 80–120 kg/ha. The farmer manually weeds the land twice a year. 'Cotton dust' is applied at 20–25 kg/ha to control chickpea podborer and aphids. Losses are usually very high during infection. This sometimes results from the farmer's lack of knowledge of technically advanced methods and application.

The harvesting is done by hand 3½ to 4 months after planting. The crop is dried and carried to the threshing floor (a hard flat area) and threshed by an animal-drawn thresher or tractor. In the Hauran, the chickpeas cannot be harvested with a combine harvester because the land is rough and full of stones.

The yield in recent years has ranged between 290 and 950 kg/ha. There are several reasons for these low yields. These are:

1. Scarce rainfall during the planting seasons in 1973, 1975 and 1979 in Hauran.
2. Rainfall not distributed uniformly in the season.
3. Late planting date.
4. Poor land preparation (the farmer believes that planting costs will be reduced if he reduces land preparation).
5. Broadcasting of seed (the farmer may increase the seed rate; some seeds may not germinate).
6. Lack of adequate weed control.
7. Crop infected with several pathogens such as blight, wilt, rust and root rot, as well as insects and pests. The farmer cannot adequately control these and he therefore loses yield.
8. High-yielding cultivars resistant to frost and disease are not yet available.

The yield could possibly be increased to more than 2000 kg/ha if these problems are solved.

Ascochyta Blight Verification Trials

Ascochyta blight is prevalent in the wetter areas of Syria particularly at the time of early sowing. This disease is commonly found in West Hauran, Al Ghab, and Tar El Oula (West Hama). It is also found in the north-west areas of Syria. The spread of this disease in spring chickpea ranges between 5 and 30%. ICARDA sent four new lines to be planted and tested in a joint verification trial; three of these were winter lines: ILC 482 (Turkish origin), ILC 195 (Russian) and ILC 215 (American). The spring variety in the trial was ILC 263. Local landrace was used as check.

The experiment was planted in 1979 at several locations in Syria (in Jillin, Ezra, Homs and Hama) for the first time to test for resistance to blight. This trial was conducted again in the 1980 season.

Line ILC 482 was 100% resistant to blight; its yield ranged from 1800 to 3000 kg/ha. Lines ILC 195 and ILC 215 had a very low percentage (3 to 5%) of infection. These results are in contrast to the local landrace which cannot tolerate cold and has a low resistance to blight (75% infection). These trials were conducted in the 1981 season, in addition to other sites, at Himo and Al Ghab to ensure that the results obained were reliable. Line ILC 482 was also tested in the spring for comparison with the local landrace. The results have not yet been obtained.

Chickpea Research by the Directorate of Agriculture

For 6 years the Directorate has planted observation row plots of several chickpea cultivars obtained from the Food and Agriculture Organisation (FAO) to study their morphological and technological characteristics. Nine promising cultivars were selected and planted for comparison with the local landrace. Four cultivars, Borvez, Coliacan (Mexican), Nobokhwa and Registered 466 (Spanish), had large seed, wrinkled seed coat, white color and good cooking quality. Other lines studied included 12–71–10013, 12–71–05473, 12–71–10016, 12–71–10014 and 12–71–10031. The seeds of these cultivars were medium to large, the seed coat was wrinkled and the seed color faded. This experiment was planted at Jillin, Ezra, Al Ghab and Himo. The planting took place in February for two to three seasons. The local landrace was highest yielding at Jillin, Ezra and Himo (Table 2). The Mexican and Spanish cultivars outyielded the other cultivars due to favorable morphological characteristics. Nobokhwa outyielded the others in the wetter areas.

Another experiment compared 10 lines of winter chickpea from ICARDA. These were planted in the 1980 season at Jillin. In this experiment, ILC 482 outyielded the others due to its high resistance to blight. This experiment was

Table 2
Comparison of the growth, seed characteristics and yield of 10 chickpea genotypes.

Genotype	Duration of crop (days)	Plant height (cm)	Seed color	Testa wrinkling	100-seed weight (g)	Yield average (kg/ha)	Protein (%)
Local	116	36	Beige	Medium	44.5	1708	19.89
Brovez (Mexican)	118	40	Faded blond	Much	53.0	1280	17.84
Coliacan (Mexican)	115	42	Blond	Much	55.0	1301	19.60
Nobokhwa (Mexican)	115	42	Faded beige	Much	54.0	1402	20.00
Regist. 466 (Spanish)	115	42	Beige	Much	53.0	1380	19.95
12-71-10013 (American)	188	42	Faded blond	Medium	32.1	1382	
12-71-5473 (American)	117	41	Blond	Medium	33.2	1440	
12-71-10016 (American)	117	39	Blond	Medium	31.1	1380	
12-71-10014 (American)	116	41	Beige	Medium	35.0	1407	
12-71-10031 (American)	117	39	Blond	Medium	33.5	1376	

distributed this season to six locations: Al Ghab, Homs, Himo, Ezra, Jillin and Lattaqieh, for confirmation of previous results.

In addition, comparative experiments on 25 spring types with large seeds (from ICARDA) were planted at three locations: Jillin, Ezra, and Karahta.

To fulfill the objective of obtaining a high-yielding, large-seeded genotype resistant to ascochyta blight, the Directorate has started a breeding program in collaboration with ICARDA.

Experimental work on winter chickpeas in Syria is also being conducted. To develop winter planting, the following steps will have to be taken:

1. Providing winter cultivars preferred by the consumer.
2. Testing these cultivars in experiments for two or more seasons to ensure that the obtained characteristics are correct. Ensure transfer of developed technology.
3. Growing nucleus seeds of improved cultivars in field verification trials. This will ensure seed increase and quality control.
4. The Ministry of Agriculture chooses the superior cultivars and gives them to the Seed Production Institute to increase and release to farmers.

5. When a new variety appears, it is disributed to farmers as before. The previous steps are followed; it is then distributed to replace the old seeds.

The Agricultural Extension Department may play a role through organizing several demonstrations to explain the characteristics of winter chickpea planting and transfer the information obtained from the research. The areas to be planted with winter chickpeas cannot be estimated until the farmer is convinced of the benefits he will receive from this planting, since this is new to him.

Summary and Recommendations

In general, for improving chickpea cultivation in Syria we suggest the following:

1. Mechanize chickpea cultivation (use of drill and combine harvester).
2. Identify herbicides and method of their application for the control of weeds of chickpea fields.
3. Make high-yielding cultivars available to the farmer.
4. Disseminate information relevant to winter chickpea, its characteristics and agricultural methods, through extension workers.
5. Disseminate results of agricultural research work.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4-7 May 1981, Aleppo, Syria

Chickpea Production in Lebanon

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Distribution and Production

Chickpea (*Cicer arietinum* L.) is the most important food legume crop in Lebanon. The main chickpea producing area is in the Beqa'a Valley, though a small hectarage can be found in various parts of Lebanon. The valley falls in the semi-arid region with a continental climate. It is at an altitude of 900 m above sea level with average rainfall ranging from 250-600 mm. However, chickpeas are not grown in areas where average rainfall is lower than 400 mm. Recent statistics on total hectarage and production are not available. FAO (1977) estimated the chickpea area to be 3000 hectares with a total production of 3000 tonnes. The current production level does not satisfy the demand of the local market. Consequently large quantities of chickpeas are imported, mainly from Turkey, particularly for canning and for the one-kilogram packages of cleaned seed sold in the retail market.

Current Production Practices

Chickpeas are grown as a spring crop in a 3-year rotation, after cereals. Land preparation starts in early fall. Deep plowing is done, mainly with a moldboard plow followed by using a local plow to break large clods thereby leaving a fairly rough surface. Next, the land is cultivated to control weeds and refine the seedbed. Planting is then done, sometime between mid-March to mid-April depending on rainfall distribution. Planting dates are generally earlier in the lowland coastal plains. The seed is hand broadcast at the rate of 150 kg/ha. Phosphorus is sometimes added at the rate of 50-75 kg/ha P_2O_5 at planting time. Seeds are covered with soil by a tractor-driven "five-bottom" Arab plow or by an old conventional plow driven by animal power. The crop is raised on residual moisture. Few farmers use supplemental irrigation. Harvesting is done by hand

and threshing is done either by using cereal threshers or an animal-drawn thresher, followed by winnowing. Grain yield of dryland chickpeas ranges from 900-1300 kg/ha. Yields after supplemental irrigation may go up to 3500 kg/ha. Supplemental irrigation is gaining more importance in recent years because of the ever-increasing prices of chickpeas (1kg sells for more than US$1).

Production Constraints

The major limiting factors to increasing production in chickpeas are the following:

Moisture stress
Dryland chickpeas sown in early spring are usually subjected to moisture stress particularly during flowering and pod filling stages. This reduces yield tremendously. As a spring crop, chickpeas have little or no chance of competing with the intensive and high-return fruit and vegetable crops grown in irrigated area.

Low yield potential of cultivars used
So far widely adapted chickpea cultivars with high yield potential are not available to farmers.

Costly production operations
Almost all production operations of chickpeas are by hand. Hand labor in Lebanon is scarce, expensive and in most cases not available for the tedious harvesting operation of chickpeas. Lack of mechanization in planting and harvesting result in very high labor costs.

Poor agronomic practices
Late sowing, poor seed bed preparation and lack of fertilizer use contribute to low yield levels.

Absence of control measures for insect-pests and diseases
The yield of chickpeas makes the use of pest control measures not economically feasible. The podworm (*Heliothis* spp.) which is a serious pest on chickpea in the Beqa'a Valley is not controlled.

Lack of chemical weed control
Effective herbicides are not available for chickpeas under the Beqa'a Valley conditions. In most cases, weeding is done only once by cultivation, just before planting. Weed competition reduces yield to a great extent.

Excessive postharvest losses.
Postharvest mishandling may cause seed losses to reach 20%.

Ascochyta Blight

Although present in Lebanon, ascochyta blight is not a serious problem on spring chickpeas. In the major chickpea-growing area, the Beqa'a Valley, low relative humidity during the spring season does not favor the occurrence and spread of the disease. Lebanese local cultivars tested by ICARDA in the Terbol Research Station were highly susceptible to ascochyta blight. This may be the main reason for not growing chickpeas as a winter crop since most Lebanese local cultivars are fairly tolerant to the cold weather prevailing in the valley during the winter season.

A detailed study on faba bean, chickpea and lentil seed health testing by Khan (1979) at the American University of Beirut was made on 15 seed samples collected from six different areas in Lebanon. The study showed that ascochyta blight was not found on any of the chickpea samples. However, *Ascochyta* spp. isolates were found on faba beans (*Vicia faba*) and lentils (*Lens culinaris*). In faba beans, the incidence was 40, 5, and 5% on seed coat, embryo and cotyledons, respectively.

Winter Sowing

Winter chickpeas have a great potential in Lebanon considering the expected increase in yield level due to the extension of the growing season and the elimination or minimization of the moisture stress during flowering and pod filling. In light of the insufficient local production to satisfy market demand and high prices of chickpea, more hectarage will be converted to chickpeas if they are sown in winter. The magnitude of this change will depend to a great extent on the improvement made to eliminate or minimize the other constraints of production mentioned earlier. However, priorities should be given to mechanize planting and harvesting, weed control, fertilization and better seedbed preparation.

In cooperation bewtween ICARDA and the Faculty of Agricultural and Food Sciences, American University of Beirut (FAFS-AUB), work on winter sowing of chickpeas in Lebanon is already under way at Terbol Research Station and at the Agricultural Research and Education Center (AREC) of the American University of Beirut. Lebanese local cultivars are being compared with two promising kabuli chickpea accessions (ILC 482 and 484) in large replicated plots at the AREC. These accessions are high yielding, resistant to ascochyta blight and cold tolerant. In addition, a winter chickpea trial (CIYT–W) is being evaluated this

season. Based on the results, planning will be made in cooperation with the Agronomy/Extension personnel stationed at AREC to move to verification field trials on farmers' fields. The Agronomy/Extension activity is a new one at AREC and is supported by the Near East Foundation to help Lebanese farmers in coordination with the Ministry of Agriculture Extension Department.

Other Research Activities

Other research work is being done on yield improvement, weed control, tolerance to adverse conditions and the technology of handling and utilization of chickpeas. Some of the research highlights include the evaluation of 49 accessions of kabuli chickpeas from 14 different countries under irrigated and moisture stress conditions. A highly significant correlation ($r = 0.56$) was found between the performance of these accessions under the two different conditions. Lebanese local cultivars ranked 18th and 22nd under irrigated and moisture stress conditions, respectively. The root systems of these accessions are being characterized under greenhouse conditions. Different types of canopy architecture were evaluated under different population densities. Tall Russian cultivars (ILC 193 and 196) grown at a relatively high population density (264,000 plants/ha) on an average outyielded the local cultivar grown at the conventional population density (132,000 plants/ha) by 10%. These tall types may be harvested mechanically. However, their seed is a little smaller than the local cultivar. Several trials and screening nurseries are being evaluated this season.

References

FAO. 1977. FAO Production Yearbook. Food and Agriculture Organization of the United Nations. Rome, Italy. 296pp.

KAHN, B.A. 1979. Seed Health Testing of Broadbean, Chickpea and Lentil. M.S. Thesis. Faculty of Agricultural and Food Sciences, American University of Beirut, Beirut, Lebanon. 118pp.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4-7 May 1981, Aleppo, Syria

Chickpea Production in Jordan

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Jordan has a classically Mediterranean climate, characterized by a warm dry summer and mild winter. The rainy period is confined to the eight cooler months of the year, October to May. Autumn rainfall is less than in the spring and far less than winter.

Agricultural Zones

The East Bank of Jordan can be divided into five zones (Fig. 1):
1. *Arid zone (Badia).* Average annual rainfall is less than 200 mm; this area is for the development of grazing and meat production through raising sheep and goats.
2. *Marginal zone.* Average annual rainfall ranges between 200 and 350 mm. Areas receiving 200–250 mm are considered as barley production areas. Areas receiving 250–350 mm are utilized mainly for wheat and legume crops.
3. *Semi-arid zone.* Average annual rainfall ranges from 350 to 500 mm. This area is used for wheat, legumes and summer crop production.
4. *Semi-humid zone.* It receives 500–800 mm and is utilized for the production of field crops and summer vegetables on the one hand, and also for fruit trees production, depending on land slope.
5. *The Ghor zone (Jordan Valley).* It lies between 200–350 meters below sea level and experiences hot summers and warm winters. It occupies about 100,000 hectares. Irrigation water is available, and three to four crops can be produced annually in many rotations. Vegetables are the dominant crops produced.

Production Practices

Chickpea is usually cultivated in the rainfed areas and is mainly planted in March. It is considered as a spring or summer crop. It is used as part of a 3-year rotation with cereals and summer vegetables.

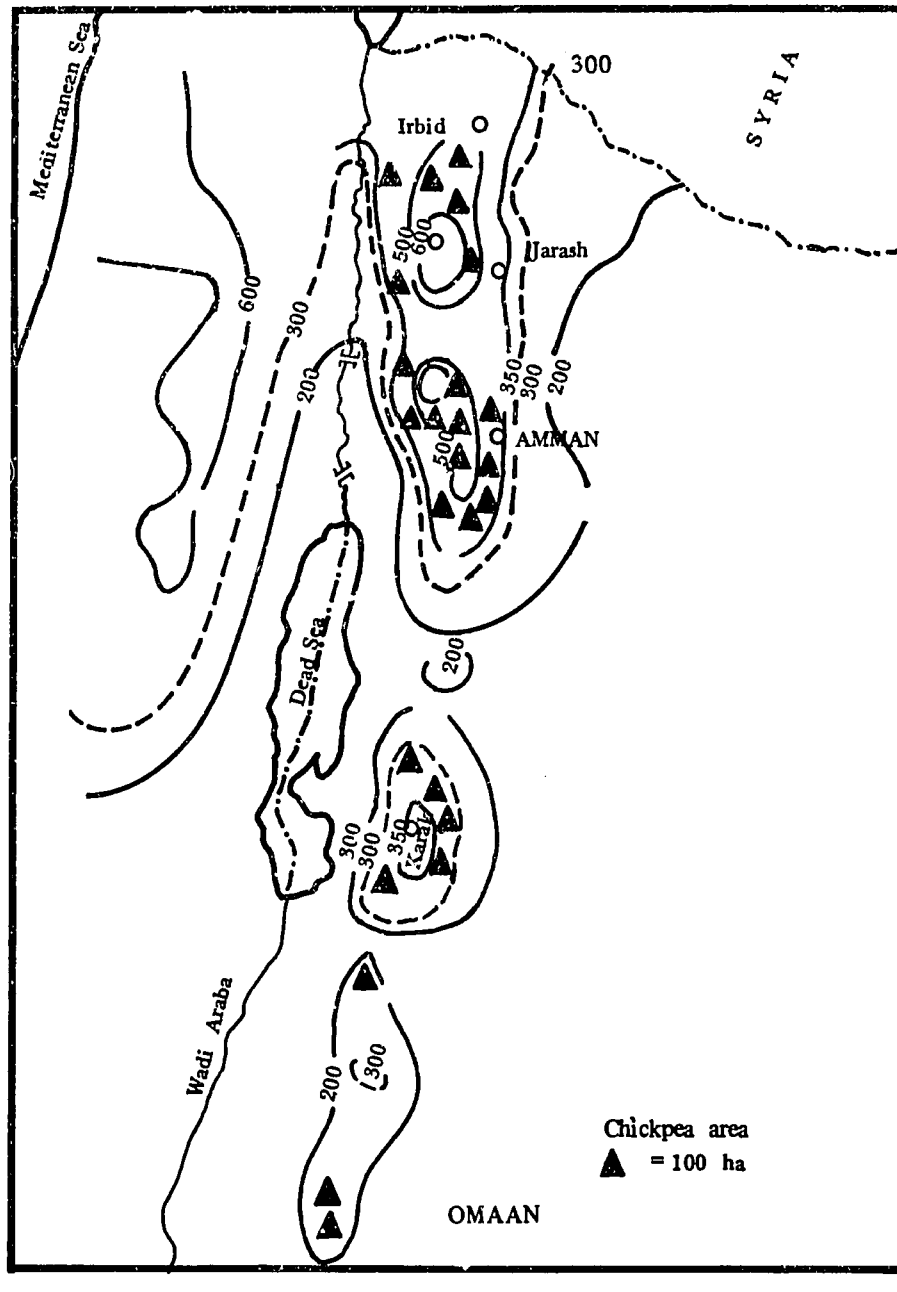

Figure 1. Distribution of chickpea cultivation in Jordan. Numbers on the countours show annual rainfall in mm.

Seedbed preparation is very minimal; disc plowing is used directly after harvesting the cereal crop. Then prior to planting and after the rain, the land is disced for weed control. If an animal plow is used, seed is put into the plow furrows which are 30–40 cm apart. The distance between seeds in the furrow is 10–15 cm. Where tractors are used, seeds are hand broadcasted and covered by a disc harrow. The local seeds are planted at 80–100 kg/ha. Hand weeding is practised.

Harvesting is done by hand; the crop is pulled from the ground,gathered in small heaps, left to dry for a while, then hauled by tractors to larger piles in the farmer's yards in the village. Threshing is carried out by animals, tractors or local stationary machines; yield losses are high due to these operations.

Fertilizers are not used, the *Rhizobium* inoculation is not practised. However, natural *Rhizobia* have been found to exist in all areas of chickpea production. Very good nodulation in all the experimental sites in the different areas was observed this year.

Utilization and Marketing

Chickpea is considered to be a very useful protein source in the diet. Very small amounts are utilized directly as fresh seeds before the full maturity of the crop. However, chickpea is mainly used as dry seeds. They are soaked, cooked and utilized in many dishes, the most popular being "Homos Bethenah" which is a dish served in most homes and in all restaurants. Chickpea is also included in some small industries.

Jordan imports relatively large quantities of this crop (Table 1); in some years imports have been valued at about one million US dollars.

Ascochyta Blight and Winter Sowing

The history of ascochyta blight on chickpea in Jordan is not well documented. Pathologists believe that the disease has existed for many years. Severe outbreaks on chickpeas have not been reported. The main reason is that farmers grow chickpea as a spring crop in March–April, when the disease incidence is largely reduced.

It is very difficult to estimate the losses due to this disease, since many factors are responsible for the low yields; some of these are late planting, *Heliothis* damage and the very primitive cultural practices used by the farmers.

In Jordan it seems that farmers delay planting to avoid "cold damage", (which is their interpretation of the disease). They are aware that "cold damage" is associated with early sowing. None of the farmers is aware that the damage is caused by ascochyta blight.

This year, demonstration trials were conducted in three parts of Jordan in

Table 1
Area, production and yield of chickpea in Jordan, 1970–1980.

Year	Area (ha)	Production (t)	Yield (kg/ha)	Yield (kg/ha) for districts				
				Irbid	Amman	Balka	Karak	Ma'an
1970	1446	678	469	625	470	501	149	–
1971	1658	1122	677	626	808	801	514	339
1972	2823	2597	920	714	1261	701	611	530
1973	3965	2579	650	442	821	152	190	–
1974	5662	3792	670	698	683	504	681	383
1975	3596	1499	417	332	441	403	540	297
1976	1892	778	411	471	435	500	153	273
1977	3216	1545	480	471	490	302	610	273
1978	2339	1309	560	575	631	153	550	283
1979	1766	733	415	329	508	121	353	229
1980	2230	1185	531					

Source: Department of Statistics, Ministry of Agriculture, HKJ.

collaboration with the Faculty of Agriculture/University of Jordan, the Ministry of Agriculture, and ICARDA. The sites chosen were Marrow in the north, Mshaqar in the center, and Rabba in the south. At each location, 0.5 ha of the line ILC 482, which is resistant to ascochyta blight were planted in early January, and another 0.5 ha were planted to the local Jordanian in March, adjacent to the winter planted plots. In another small demonstration, the resistant lines ILC 482, ILC 72, and ILC 484 along with the local Jordanian were planted in November in Jubeiha and Marrow. The purpose was to observe the disease and to increase the seed of the resistant lines.

Our observations during 10–15 March indicated that *Ascochyta* incidence on the early-planted resistant variety was very severe, and almost every plant carried the symptoms. However, one month later, an excellent recovery was observed, but each plant had only one or two branches. Samples of the infected plants were tested, and ascochyta blight was found to be the cause of the disease. More detailed information will be taken on both winter- and spring-planted fields.

The importance of winter sowing of chickpeas was demonstrated in recent years in trials conducted by the Faculty of Agriculture and the Ministry of Agriculture; the results indicated that early sowing gave almost double the yield of late-planted chickpeas. However, in all these trials Jordan local was used and no ascochyta blight incidence was reported.

Farmers may not object to changing from late planting; in fact, this will be more convenient to their cropping system since all cultural operations can be

carried out at the same time with wheat and lentil cultivation. However, three problems should be solved before any real change could be expected. The first is the ascochyta blight damage. This problem could be solved by resistant varieties; second, the high weed population which usually accompanies winter planting must be controlled and herbicides should be the main means to solve this problem; third, farmers should be convinced that very high yields could be achieved by winter planting. Our on-farm demonstrations and date of planting trials are the first step in thiat direction. More trials and demonstrations on herbicides and other cultural practices are included in the program for next year.

Strategy for Introducing Winter Planting and Suggested Cropping System

The problems facing the shifting to winter planting of chickpeas are not very difficult to solve, especially with the identification of *Ascochyta*-resistant source. However, a few years are needed for the results to be demonstrated to farmers.

In setting up a strategy for chickpea winter planting and chickpea production in Jordan, the following must be taken into account:

1. Chickpea yields in Jordan are very low (Table 1). This is mainly due to the primitive methods of production, the very low inputs used, and some chickpeas being grown in areas with a very low rainfall, e.g. the Ma'an district.
2. Yields are highly correlated with rainfall; the highest rainfall was received in 1972 and 1974, and the highest yields were recorded in these two seasons.
3. Chickpea consumption in Jordan, which is calculated as Imports + Production minus Exports ranged from 6183 tonnes (1974) to 1635 tonnes (1976).
4. If it is assumed that annual domestic consumption at present is around 7000 t, and the average yield for winter-planted chickpeas under relatively good production practices is 2000 kg/ha, then 3500 ha should be planted to chickpea annually to meet the local demands. The amount of improved seeds required for planting such an area will be 350 t, using a seeding rate of 100 kg/ha.
5. The area required for producing this quantity of improved seeds is 175 ha, which could be easily provided, either through the governmental stations and/or by special contract with selected farmers.

Our previous calculations were based on two assumptions; the average yield under winter planting will be 2000 kg/ha, however, a higher yield could be expected. On the other hand, the production is for domestic consumption, and this could be increased if demands for exports increased.

Chickpea should be planted in Jordan in areas receiving at least 300 mm rainfall and with a moderate slope between 0–15%. From data collected on land in Jordan (Tables 2, 3, and 4), areas locatd under the semi-arid and semi-humid zones are around 234,800 ha. Of these, 26,897 ha have a moderate slope (0–9%)

Table 2
Area (hectare) in different agricultural zones and different districts of the East Bank of Jordan.

District	Arid Zone (< 200 mm)	Marginal zone (200–350 mm)	Semi-arid (350–500 mm)	Semi-humid (500–800 mm)	Total
Irbid	2,094,060	137,696	84,908	55,360	7,371,025
Amman	1,650,389	151,574	26,725	20,492	1,849,180
Balka	36,928	27,606	19,219	23,048	106,801
Karak	257,657	204,418	6,048	–	468,124
Ma'an	4,417,866	72,104			4,459,970
Total	8,456,900	563,400	135,900	98,900	9,225,100

Source: Agriculture Ecological Zones in Jordan. Working paper. March 1979. Agricultural Research and Extension Department, Amman.

Table 3
Classification of agricultural zones of the East Bank of Jordan according to districts and slope (area in hectares).

	Marginal Zone		Semi-arid Zone		Semi-humid Zone	
District	0–8%	9–25%	0–8%	9–25%	0–8%	9–25%
Irbid	72,907	57,843	13,400	41,258	606	35,167
Amman	70,656	50,562	10,632	12,031		14,844
Balka	7,718	11,812		9,125		11,892
Karak	78,079	83,001	2,259	2,458		
Ma'an	6,810	25,125				
Total	236,170	228,343	26,291	64,872	606	61,903

Source: Same as for Table 2.

and are perfect for chickpea production. More areas under the marginal zone were rainfall is between 300-350 mm could be added to this area. Also, areas with a slope between 9 and 15% could be used for chickpea production (but the statistics in the tables do not consider these areas).

The crop rotation for rainfed areas which receive rainfall exceeding 300 mm, is

Table 4
Topographical classification of land of the East Bank of Jordan, according to slope and agricultural zones (area in hectares).

Agricultural Zones	Rainfall	Slope			
		0–8%	9%–25%	25%	Total
Arid Zone	<200 mm	7,822,278	414,060	220,562	8,456,900
Marginal Zone	200–350 mm	236,170	228,343	98,887	563,400
Semi-arid	350–500 mm	26,291	64,872	44,737	135,900
Semi-humid	500–800 mm	606	61,903	36,391	98,900
Total		8,085,345	769,178	400,577	9,244,100

Source: Same as for Table 2.

usually a 3-year rotation and consists of cereals (mainly wheat), legumes (mainly lentil, chickpea, vetch, and to a lesser extent, faba bean); and summer vegetables (mainly tomato, watermelon and yellow melon). Thus to suggest a cropping system under this rotation, chickpea could occupy one-third of the area under legumes. That is, if 9000 ha could be annually planted to legumes, then around 3000 ha could be plantd to chickpea. This area could be doubled if areas in the marginal zone, and areas with a slope between 9 and 15% in the three different zones are included.

The major areas for chickpea production are located in three districts – Irbid, Amman, and Karak (Table 5). These districts should be considered for increas-

Table 5
Area and production of chickpea in the different districts, as a percentage of the Jordan total.

District	Area (%)	Production (%)
Irbid	28.13	25.42
Amman	42.99	50.23
Balka	6.66	5.58
Karak	19.17	17.15
Ma'an	3.04	1.62

Source: Same as for Table 2.

ing chickpea production and expansion into other areas will depend upon the demand for consumption and exports.

The government should be seriously involved in establishing a cropping system for crops in the rainfed area and legislation in this direction must be developed. If a cropping system is followed, production and prices could be stabilized.

Discussion

D. Nygaard

Wheat is also planted late in Jordan sometimes; once the rain starts it is difficult to get on the fields before February or March. Will the compromise you suggest, intermediate planting date, land into a similar problem?

N. Haddad

No it will not. The reason is that, if wheat is delayed to the end of January, the crop will be very poor and it may be too late for planting the crop after that. However, with chickpeas the situation is different. Since you can plant the chickpeas as late as end of March, you will never lose your crop because of delayed planting as in case of wheat, and under the worst situation you will plant it as early spring chickpeas. Further, the area under chickpeas will be very small compared to that under wheat, so it will be very easy to prepare the land with a very short break in rainfall. Thus I believe that my suggestion for an intermediate date of planting should work very well in Jordan and similar countries.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Cyprus Country Report on Chickpeas

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Chickpea is one of the traditionally grown crops in Cyprus. As human food, dry chickpea grain is used either boiled, or made into hommos, or roasted and eaten as snack.

Area, yields and production data are shown in Table 1. Imports, exports and their respective values are shown in Table 2, which also shows the consumption, i.e. production + imports-exports; consumption includes the amount of chickpea which goes into the canning industry for preparing hommos, the biggest part of which is exported. The distribution of chickpea production is shown in Figure 1.

The area and production of chickpea peaked in 1979 (Tables 1 and 2) due to the high prices that were obtained by chickpea and food legumes in general, during that period in Cyprus. Exports in 1977 and 1978 were quite high – mainly exports of chickpea seed (Anon. 1981). Also, 181 and 122 tonnes of chickpea

Table 1
Area, yields and production of chickpea in Cyprus.

Year	Area (ha)	Yield (kg/ha)	Production (t)
1960	682	447	305
1970	401	761	305
1971	1338	493	660
1972	1472	276	406
1973	669	152	102
1974	1070	285	305
1975	535	570	305
1976	535	761	406
1977	669	911	610
1978	669	897	600
1979	1205	705	850

Table 2
Imports, exports and consumption of chickpeas.

Year	Imports		Exports		Consumption[2]
	t	C£/t[1]	t	C£/t[1]	t
1960	570	41.1	45	63.6	830
1970	113	72.8	55	116.8	363
1971	105	80.1	509	103.8	256
1972	95	142.9	195	116.8	306
1973	410	153.9	27	134.0	485
1974	257	119.7	5	160.8	567
1975	176	129.7	33	264.8	448
1976	325	137.5	52	342.8	679
1977	302	198.3	143	292.4	769
1978	221	217.5	294	386.2	527
1979	167	260.1	20	371.6	997
1980[a]	0	–	5.4	343.9	–

1. C£ 1 = US $2.6.
2. Consumption = production + imports – exports
a. Until November 1980.

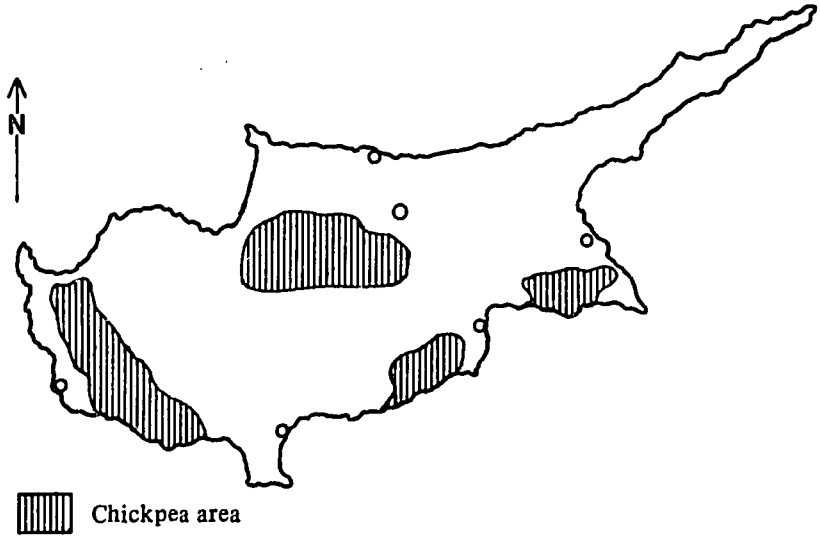

Figure 1. Chickpea-growing areas in Cyprus.

were absorbed by the canning industry in those 2 years. This situation stimulated the high production of 1979 which, associated with considerable imports, led to a serious problem of surplus. Consequently prices fell and latest reports put them at as low as C£ 120 per tonne on the local market; both area and production were reduced in 1980 and further reduced in 1981 (official statistics are not available yet.)

These events indicate that marketing of chickpea is difficult and unreliable and this constitutes one of the major limiting factors to increasing production. Consequently the cost of production needs to be reduced. Problems like mechanization (especially harvesting) and weed control also continue to be limiting factors.

Production Practices

Chickpea is grown in rotation with cereals or vegetables under rainfed conditions. Occasionally spate (i.e. river-flood) irrigation is practised, especially in the central area, to flood the fields, usually prior to sowing. Producers obtain their seed from their previous crop or from other chickpea growers. The Seed Production Centre finds it difficult to dispense seed of the local variety but they anticipate that seed of new, improved varieties will be easily dispensed. At present, all chickpea fields are sown almost exclusively with the local landrace which has a high purity percentage. Recent variety trials have shown that new, improved cultivars could replace the local landrace (Xenophotos, E., personal communication).

Fields are prepared by plowing, followed by one or two lighter cultivations, as soon as the weather and field conditions permit it in January or early February. The majority of sowing is done from the middle of February to the middle of March. Winter sowing is not practised. Seed rates used are low, around 75 kg/ha, and they vary considerably. Higher rates of 100–125 kg/ha are recommended by the Department of Agriculture. The seed is either broadcasted or hand sown in furrows; some progressive growers are now using locally constructed cereal drills. Small doses of N fertilizer (up to 20 kg N/ha) and P fertilizer (40–50 kg P_2O_5/ha) are applied at sowing.

Weed control is by hand hoeing. Diseases are not a problem and occasional attacks by insects are controlled with readily available insecticides.

At harvest, plants are hand pulled, heaped to dry and then threshed with stationary threshers. The straw is used for feeding the livestock, and is highly priced.

Generally, chickpea is grown on a limited scale in scattered fields. Some major limitations to chickpea production are: (a) local consumption is very low (Haricot beans and faba beans are preferred); (b) cost of production is high due to the

labor involved; (c) limited export possiblities due to competitive prices prevailing in the international market.

Ascochyta Blight

Although ascochyta blight is listed among the diseases attacking chickpea in Cyprus, its importance is minimal. The first record of its occurrence described the disease as causing appreciable economic losses, very destructive on local cultivars and apparently of recent introduction, when referring to its appearance in April 1954 at the Central-North part of Cyprus (Gregoriou and Papadopoulos 1957). It was further stated that some resistant cultivars tested locally, showed considerable promise. There appear to be no other records of occurrence or severe epidemics of the disease, nor of any substantial yield losses in Cyprus. Consequently no research program on ascochyta blight was undertaken in the past, or is in progress at present.

Various production factors in Cyprus may be responsible for the near elimination of the disease: (a) spring sowing with rising temperatures and low rainfall normally falling on isolated days, does not favor its spread, (b) chickpea stubbles are removed from the field and used as livestock feed thus leaving no debris to carry the disease, (c) scattered fields of small area make it impossible for the discase to spread from one field to another, and (d) chickpea is grown in rotation with other crops which prevents the carry-over of the disease from season to season. All these factors seem to have led to a considerable depletion of the available amount of disease inoculum.

Winter Sowing

Winter sowing is not practised now on a commercial scale. If it proves to be a feasible and profitable practice, it can be expected that a big percentage of the spring-sown area will be converted to winter sowing.

Strategy for Introducing Winter Sowing

The advantage of winter sowing over spring sowing must first be established beyond any doubt. From preliminary trials it is evident that there are yield increases in both grain and straw of chickpea when sown in early winter, as compared with spring sowing. No frost damage or ascochyta incidence were recorded; plants survived through the winter but flowers did not produce pods until after the beginning of April. This resulted in the lowest pods being higher above the ground than with spring-sown plants, which is an advantage as regards combine harvesting. Weed control is a problem with winter sowing. Chemical weed control trials are in progress and there are promising results.

The advantages of winter sowing must be weighed against the problems arising with its introduction, such as the need for weed control and the possibility of losses from ascochyta blight. Agronomic practices such as row spacing and plant population might have to be readjusted to suit the new practice. Finally, an overall economic analysis and comparison of winter and spring sowing will be necessary.

Research and Extension

The Seed Production Centre of the Department of Agriculture is well organized and efficient. New cultivars with desirable characteristics, e.g. high yield and resistance to *Ascochyta*, can be multiplied and sold to the farmers without delay.

In Cyprus there are good links between research and extension services. Research on practical farming isssues is carried out at the Agricultural Research Institute (ARI). This work includes testing of new cultivars, methods of conducting farming operations, plant protection and studies on agricultural economics.

With regard to chickpea research work, the following findings were obtained in recent trials: (a) tall varieties exist that can be easily combine-harvested; (b) it is impossible to harvest the short variety now grown, by a combine harvester, without modifying the pick-up; (c) harvesting in stages, i.e. mowing and baling when the crop is approaching maturity and then threshing with a stationary thresher can be successfully practised; (d) sowing at about 10 cm depth in the spring gave better results than sowing at 0–5 cm depth; (e) sowing can be done with a conventional drill, but higher rates must be used to allow for seed breakages.

The work carried out at the ARI has direct application in practice. The extension service personnel are involved in the identification of the problems. The results of ressearch are both communicated and demonstrated to the extension service personnel who then inform and help farmers with the application of new findings.

References

ANONYMOUS. 1981. Time Series Data on Vegetable and Field Crops of Cyprus 1960–1980. Agricultural Economics Section of the Cyprus Agricultural Research Institute.

ARI. Annual Reports. Agricultural Research Institute, Cyprus.

GEORGIOU, G.P. and PAPADOPOULOS, C. 1957. A second list of Cyprus fungi. Technical Bulletin TB-5.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Chickpea Research in Iran

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Chickpea is one of the main legume crops in Iran. The most important disease affecting this crop in regions such as Azerbaidjan, Fars, Gorgan, Kurdistan and Khouzistan is ascochyta blight.

Research on Ascochyta Blight

The Regional Pulse Improvement Project has carried out research on this disease and on different methods for reducing the damage (Kaiser *et al.* 1968; Kaiser 1972; Kaiser 1973; Mossahebi 1967; Okhovat 1969; Okhovat 1974). The following results were obtained:

1. Use of certified seeds (free from small, infected, shrivelled seeds or seeds produced in disease-free areas) and seed treatment with Thiabendazole or Daconil is recommended.

2. In high rainfall areas, damage can be reduced by a proper planting date. In some areas late planting at the end of spring rainfall is recommended to avoid severe infection.

3. The chickpea collection was evaluated and many ascochyta blight-resistant lines among black-seeded types were identified. Some of these lines are being used in our crossing program in order to create high-yielding, white-seeded, blight-resistant cultivars.

Research on Winter Sowing

During the last 3 years, a new program is attempting to find cold-tolerant

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cultivars which could be planted in winter under rainfed conditions in the Karaj area. During 1978, 650 white and 540 black-seeded lines from our chickpea collection were planted in winter, without irrigation. Twenty-seven lines were selected that exhibited tolerance to cold, blight and drought. Their yields were evaluated in 1979 in a replicated trial, and in 1980 the most productive lines were tested in order to determine the suitable date of planting.

Research Activities, 1980-81

1. Observation nurseries: 90 lines from our collection were planted to determine drought, cold, and blight-resistant material.

2. White and black chickpeas yield test: 10 lines of each were planted in a replicated yield trial.

3. Plant spacing and density trial: A high yielding cultivar was planted under two row spacings (20 and 50 cm) and three seeding rates (60, 80, and 100 kg/ha) in order to determine the best combination of these two factors.

4. Herbicide trial: Different herbicides are being tested in a replicted trial to control weeds in winter sown chickpeas.

In the future we hope to conduct research programs in cooperation with ICARDA, especially on winter planting.

References

KAISER, W.J. 1972. Occurrence of three fungal diseases of chickpea in Iran. FAO Plant Prot. Bull. 20(4):73–79.

KAISER, W.J. 1973. Factors affecting growth, sporulation, pathogenicity and survival of *Ascochyta rabiei*. Mycologia 65:444–457.

KAISER, W.J., DANESH, D., OKHOVAT, M. and MOSSAHEBI, H. 1968. Diseases of pulse crops (edible legumes) in Iran. Plant Dis. Reptr. 52(9):687–691.

MOSSAHEBI, H. 1967. The reason for damping off in chickpea in Iran. B.S. Thesis. Faculty of Agriculture, Tehran University.

OKHOVAT, M. 1969. Legume fungi diseases in Iran. Pages 297–312 *in* First Plant Protection Congress in Iran.

OKHOVAT, M. 1974. Chickpea blight in Iran. Regional Pulse Improvement Project, Faculty of Agriculture, Tehran University.

Discussion

M.C. Saxena

You mention that the best time of planting chickpeas is just before the onset of cold weather so that the seeds germinate but do not emerge. They then remain covered with snow for one month or so and after the snow melts away in spring, the emergence occurs and the crop gets established. Could you please tell the percent emergence in this situation? There could probably be a high loss of stand because of death of some germinated seeds.

A. Sarafi

In our experiments the percentage of germination varied from 16–68 according to genotypes, which shows the variation in cold resistance.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4-7 May 1981, Aleppo, Syria

Chickpea Production in Pakistan

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Chickpea is widely cultivated as a postmonsoon winter crop in Pakistan. In the world, Pakistan ranks second to India in terms of area occupied by chickpea.

Chickpea accounts quantitatively for a small portion of the country's total food supply, but its qualitative importance is quite significant in supplementing food nutrients in the dietary requirements of a great majority of the population. As human food it is eaten raw, boiled, roasted, or as green vegetable, as well as dhal (dry pulse after splitting). It provides a balanced diet when eaten as dhal in combination, specially with cereals. It is also one of the major constituents of various sweets. Its dry stalks and husks containing small broken pieces of grain during milling, are fed to animals.

Area, Distribution, Production and Yield

Chickpea is grown all over Pakistan but its cultivation is concentrated in selected areas. Ecologically, Pakistan can be divided into three chickpea producing regions:

Northern Region: It has high rainfall, and surface irrigation facilities also exist, but chickpea is mainly grown under rainfed conditions.

Central Region: It has highy fertile soils but the climate is mostly semi-arid. Production is mostly aided by surface irrigation but chickpea is also grown under rainfed conditions. This region can be divided into two distinct tracts, differing in rainfall, soil fertility, and geophysical features as follows: (1) Western (includes Sargodha, Mianwali, parts of Attock and Jhelum), 6–84 mm/month summer rainfall, 3–13 mm/month in winter; it is a low rainfall tract. (2) Eastern (includes Rawalpindi and Sialkot), 26–374 mm/month summer rainfall, 23–65 mm/month in winter. High rainfall tract.

Southern Region: Rainfall is scanty and agriculture is totally under irrigated

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conditions. However, chickpea is grown on residual moisture after rice without any surface irrigation.

Table 1 shows the chickpea regional area and production details for 1978–79. It is the major cash crop of rainfed areas (85%).

Table 1
Distribution of area and production under chickpea by region, 1978–79.

	Total		Percent distribution	
	Area (000 ha)	Production (000 tonnes)	Area	Production
Northern Region	125	23	10.2	4.3
(1) D.I. Khan Divn.	110	20	9.0	3.7
(2) Others	15	3	1.2	0.6
Central Region	934	399	76.4	74.3
(1) Sargodha Divn.	707	272	57.8	50.7
(2) Rawalpindi Divn.	61	28	5.0	5.2
(3) Others	166	99	13.6	18.4
Southern Region	164	115	13.4	21.5
(1) Sukkur Divn.	157	110	12.8	20.5
(2) Others	7	5	0.6	0.9
Total	1223	537		

Area, production and yield data for Pakistan as a whole are presented in Table 2. The area sown remained static from 1975–78 because the semi-dwarf, high-yielding cultivars of wheat and rice captured more area, being more profitable than chickpea. The increase in planted area during 1978–79 was due to an increase in the price of chickpea. The decline in area during 1979–80 is due to blight damage in the previous year. The area during 1980–81 is estimated to be much less, because of severe blight damage in the 1979–80 crop season. Blight drastically reduced production in the 1978–79 and 1979–80 seasons.

The national yield is very low. As the chickpea is grown under rainfed conditions, the yearly fluctuations in planted areas, production and yield/ha are largely dependent on weather conditions.

Major Limiting Factors to Increasing Production

Until recently chickpea improvement work received very little emphasis. Major attention went to cereals such as wheat, to rice and to some other cash crops.

Table 2
Area, production and yield of chickpea in Pakistan.

Years	Area (000 ha)	Production (000 tonnes)	Yield (kg/ha)
1964–66	1175	615	523
1974–75	996	550	533
1975–76	1068	601	563
1976–77	1094	649	593
1977–78	1099	614	558
1978–79	1221	538	439
1979–80	1129	313	278

Source: Crop Statistics of Pakistan, Feb 1981.

The production barriers are the absence of high-yielding disease and insect-resistant cultivars; losses caused by diseases and pests in the field and in storage; yield instability caused partly by genetic and partly by environmental factors; inadequate information on crop management and a dearth of trained manpower.

Current Cultural Practices

Chickpea is grown on a variety of soils, but saline and alkaline soils are avoided. Sandy loam and the sandy soil of the Punjab and the North West Frontier Province (NWFP) are planted to chickpea. In the Province of Sind, chickpea is grown on rice soils with a greater moisture retention capacity; no surface irrigation is needed. The crop is planted on seed beds that are free of large clods and trash. The land is prepared by giving one deep plowing followed by two or three regular plowings. Planting is done after every plowing for conserving moisture and killing germinating weeds. The tillage operations are mostly performed with bullock-drawn implements, as mechanized farming is limited and is mostly confined to high-value crops and cereals.

Nearly 80–90% of the farmers keep their own seed and the remainder purchase it from either the local market or from fellow farmers. The seed procuring agency procures and distributes very little quantity of chickpea seed. The seed rates and sowing times differ from variety to variety and area to area (Table 3).

The crop is usually sown with single colter drills in lines, 30 cm between rows and 10 cm between hills. In flooded tracts where the preparatory tillage is to be carried out hurriedly, it may be sown by broadcast. Row planting is recommended to facilitate weed control and harvesting.

The use of chemical fertilizer is not popular on chickpea and other grain

Table 3
Sowing times, rates and varieties for the main districts.

Main district	Sowing time	Seed rate (kg/ha)	Varieties
Mianwali, Bannu, D.I. Khan, Kohat Attock and Jhelum.	Mid-Sept to mid-Oct	80	C 727, C 612, C 12/34, local
Sargodha, Faisalabad, Sahiwal, Multan and Bahawalnagar.	Mid-Sept to end of Oct	80	Pb 7, C 612, C727
Jacobabad, Sukkar	Oct to early Nov	100	Local, Sanyasi, Sindhi White
Larkana and Khairpur	Oct to Nov	100	Local

legumes, although phosphatic fertilizer is recommended at the rate of 50 kg P_2O_5/ha. It is usually broadcast.

Almost all the chickpea cultivars grown in the country are susceptible to pests and diseases, specially the pod borer, wilt and blight. The most important disease found in Pakistan is blight (*Ascochyta rabiei*). Amongst the pests, the most damaging ones are pod borer (*Heliothis armigera*), cut worm (*Agrotis* spp.) and seed-weevils (*Bruchus* spp.).

Weeds in the chickpea crop are also one of the major limiting factors to high yield. Although the harmful effects of weeds are realized, the huge cost of weeding prevents farmers from doing the operation. The tedious operation of hand weeding is common in the traditional sector.

Farmers in some areas delay planting for some days until rains germinate at least one "wave" of weeds which are then killed by cultivation or harrowing before or at planting time.

Some experiments are conducted with preemergence herbicides during the 1980–81 crop season. The herbicides used include malaron, tribunil and Igran. They gave good control of weeds, without damage to the crop.

Manual harvesting is practised. Plants are left after harvesting in the field in small piles to dry and are later gathered into large heaps in the threshing yards. Hand weeding, manual harvesting etc., and the increasing costs of all these operations on one hand and low yields on the other, deprive farmers of the incentive to grow chickpea on good pieces of land.

From the fields, the chickpea plants are transported (manually, bullock carts, etc.) to threshing yards which are mostly on the edge of the village. Tarpaulins are spread out on the grounds during loading of plants to avoid seed and pod losses.

Threshing is mostly done by bullock treading, but hand flailing is also common. The threshing with bullock and subsequent manual winnowing is very labor intensive and also produces unsatisfactorily cleaned seeds.

Ascochyta Blight

Importance and Occurrence

Chickpea is cultivated as a rainfed or irrigated crop and the average yields are very low (500 kg/ha). Many factors are responsible for the low yields, which include excessive vegetative growth and poor harvest index (Shakoor and Ahsanul Haq 1980), but the most important limiting factor in exploiting the yield potential of present-day cultivars is the occurrence of blight disease caused by the fungus *Ascochyta rabiei*. It usually occurs in the rainfed areas of Sargodha and Rawalpindi divisions of Punjab Province and the D.I. Khan division of the NWFP Province. About 75% of Pakistan's production comes from these areas, thus damage from disease in these areas severely affects the stablity of chickpea production.

Yield Loss Estimates and Frequency of Severe Epidemics

Blight appeared in epidemic form in the major chickpea-growing areas of Punjab (Sargodha and Rawalpindi divn.) and NWFP (D.I. Khan divn.) in 1978–79 and reduced production by 17%. It apppeared again in severe form during 1979–80 in the same areas of the two provinces and resulted in 48% reduction in total chickpea production in the country. It has also been found to be severe in some areas during 1980–81, but the attacks are localized.

The disease epidemic in the two consecutive years has caused great loss to farmers (about US$ 90 million). Prior to 1978–79, blight appeared about every 5–8 years in Pakistan.

Control Measures Practiced

The most lasting and economical control measure is the growing of resistant cultivars. Due to the absence of resistant chickpea cultivars, the following control measures are adopted by the growers to reduce the crop failures (Ahmad *et al.* 1949):

1. Planting of healthy seeds procured from disease-free localities.
2. The diseased plants when still green but appear sick in the fields in patches are harvested and fed to animals after chaffing and mixing with other

fodders. The farmers used this practice widely this season. This helps to reduce the quantum of inoculum in the fields.

3. Crop rotation is practiced in areas where feasible so that infected fields are not brought under chickpea.
4. Mix-cropping with wheat, barley, rape and mustard etc., is also practiced.

Ascochyta Blight Research in Pakistan

The disease was present in the North West Frontier Province decades earlier than the official report of its occurrence (Sandhu 1972). In 1926–27 heavy losses were reported in the Attock district (Singh 1927).

Pathogenicity tests with *Acochyta rabiei* indicated that distinct physiological races of the pathogen do not exist in Pakistan. However, different isolates exhibit some cultural and morphological differences (Arif and Jabbar 1965).

Host resistance has received major attention as a control measure. At the University of Agriculture, Faisalabad, CS 30, V-173 and V-132 were found to be tolerant to blight. The resistance of V-132 broke down at the flowering stage while CS 30 and V-133 were poor in grain yield compared with C 727. To make use of tolerance of these lines, their seed was mixed with other high-yielding cultivars having similar seed characters, in a 50:50 ratio. It was expected that during blight-free years the loss in grain yield would be compensated by the high yielding component, while during blight years at least 50% of crop could be saved. AUG 480 (a mixture if CS 30 and AUG 426) withstood blight in Piplan, Rawalpindi and Faisalabad during 1978–79. To date, screening for blight at the University of Agriculture has shown that strains 626, 6190, 6212, KT-59/3, KT-60/3 and KT-63/3 are tolerant to chickpea blight (Aslam *et al.* 1980).

At the Nuclear Institute for Agriculture and Biology, Faisalabad, an induced mutation breeding program was initiated during 1978–79 to induce resistance against ascochyta blight in chickpea. Segregating material consisting of 20,000 M_2 single-plant progenies, 208 true breeding advanced mutant lines in M_5 generation and 23 pure lines/cultivars was screened at Faisalabad under artificial, and at Attock under natural epiphytotic conditions. Two mutant lines, CM 68 and CM 72, showed resistant reaction at both locations (Ahsanul Haq and Shakoor 1980).

The germplasm obtained from ICRISAT and ICARDA plus local collections have been screened under artificially created heavy pressure of inoculum during the 1979–80 and 1980–81 seasons at the National Agricultural Research Centre (NARC), Islamabad, Agricultural Research Institute (ARI), Peshawar (Tarnab) and the University of Agriculture, Faisalabad. Thirty-seven lines (kabuli and desi) have been identified as resistant on a 1–9 scale: ICC 76, 607, 641, 1121, 1467, 1468, 1591, 7513, 7514, 7520, 1772, ILC 72, 183, 191, 195, 201, 202, 484,

182, 192, 194, 1069, 1772, 3279, 2380, 200, NEC 138–2, NEC 1526, NEC 1256, PCU 15, 128, AUG 480, CM 72, 68, 66, 67, 57.

References

AHMAD, T., HASANIAN, S.Z. and SATTAR, A. 1949. Some popular methods of plant disease control in Pakistan. Agriculture Pakistan 1:18–22.

AHSANUL HAQ, M. and SHAKKOOR, A. 1980. Use of induced mutations for the induction of resistance against Ascochyta blight in chickpea (*Cicer arietinum*) and yellow mosaic virus in mung bean (*Vigna radiata*). Induced mutations for improvement of grain legume production. IAEA, Vienna 63:67.

ASLAM, M., Khan, M.A. and Khan, I. 1980. Success story of breeding gram resistant to Ascochyta blight. Proc. Ag. Res. Conference, 23–26 Feb 1980, Islamabad.

ARIF, A.G. and JABBAR, A. 1965. A study of physiologic specialisation in *Mycrosphaerella rabiei* Kovicevaski *Ascochyta rabiei* (Pass.) Lab., the causal organism of gram blight. West Pakistan J. Res. 3:103–121.

SANDHU, T.S. 1972. New sources of resistance to gram blight disease (*Ascochyta rabiei* Kovacevaski) Madras Agric. J. 59:41.

SHAKOOR, A., and AHSANUL HAQ, M. 1980. Plant architecture in chickpea and mung bean. Induced mutation for the improvement of grain legume production. ISEA, Vienna. 59–62.

SINGH, R.D.1927. Annual report of the Cerealist to the Government, Punjab, Lyallpur, for the year ending 30th June 1926. Report on the operations of the Department of Agriculture, Punjab for the year ending 30th June 1926, Part II (1):1–45.

Discussion

G.C. Hawtin

In view of the high and frequent incidence of aschochyta blight in Pakistan, it might well be expected that resistance could be present in local landraces. To what extent have these been collected, especially from NWFP and other endemic areas, and tested for resistance?

M. Aslam

I agree with Dr. Hawtin that there is a need for a thorough survey of chickpea crop in Punjab and NWFP to select resistant genotypes under natural conditions and ICARDA or ICRISAT could very well help in carrying out such surveys.

Y.L. Nene

Dr. Malik mentioned that in Pakistan infected plants are fed to cattle. I may mention that according to a report from Pakistan the spores which pass through the animal lose their viability.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

A Review of Research Studies on Chickpea Blight Fungus in Pakistan

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Chickpea (*Cicer arietinum* L.) occupies an important position amongst the food crops in Pakistan and is perhaps the only crop that can be successfully grown during winter in the vast *barani* (rainfed) tract of the country. However, the crop is prone to attack by two very destructive diseases, namely, ascochyta blight and wilt.

Blight caused by *Ascochyta rabiei* is particularly serious in areas receiving more than 150 mm rainfall during the chickpea growing season (Sattar 1933). On the other hand, wilt caused by *Fusarium lateritium* f. *ciceri* is generally serious in areas receiving less than 87.5 mm rainfall during the growing period. There are areas such as Thal in the Punjab (Pakistan) where these diseases co-exist (Luthra *et al.* 1943).

There is no recorded evidence on when blight was first reported in Pakistan but it seems that the disease is as old as the chickpea crop in the barani areas of the Punjab and the North West Frontier Provinces. Systematic investigations were commenced in 1929. Butler (1918) had described the fungus as *Mycosphaerella pinodes* (Berk and Blox). It was identified by Luthra (1929) as *Mycosphaerella pinodes* which Jones (1927) had also recommended. The earlier studies differentiated the blight fungus from *Ascochyta pisi* at least in possessing unicellular pycnospores, in culture characters of the fungus on oatmeal agar and a slower rate of growth than *Ascochyta pisi*. Sattar and Hafiz (1952) arrived at the following conclusions from their studies.

1. The fungus causing blight of chickpea in Pakistan is identical with *Phyllosticta rabiei* (Pass) Trotter, but should be called *Ascochyta rabiei* (Pass) Lab.
2. *Ascochyta pinodella* Jones and *Ascochyta pinodes* Jones (*Mycosphaerella pinodes*) (Berk and Blox) are confirmed as separate species distinct from *Ascochyta pisi* Lab. and *Ascochtya rabiei* (Pass) Lab.
3. Each fungus with the exception of *Mycosphaerella pinodes* and *Ascochyta pinodella* is specialized largely to its own host plant.

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4. *Mycosphaerella pinodes* and *Ascòchyta pinodella* cause severe foot rot while the others cause leaf, stem and pod blight. A fungus isolated from peas in Pakistan in association with *Ascochyta pisi* Lab. is considered to be a weak parasitic race of *Ascochyta pinodella* Jones.

Growth Requirements of the Fungus

A comparative study of nutritional requirements, germination of conidia, pathogenicity of *Ascochyta rabiei* and *Ascochyta pisi* did not indicate a high degree of specialization of parasitism in the two fungi in infecting chickpea and pea plants. Of the factors studied, any degree of specialization of parasitism that may be shown by these two fungi could only be explained on the basis of the presence of malic acid on the leaves of chickpea plants which was detrimental to the conidia of *Ascochyta pisi* (Ahmad 1959).

Sattar and Hafiz (1952) outlined optimum, maximum and minimum temperatures for growth of the fungus as 25°C, 32.5°C and below 10°C, respectively. The fungus made maximum growth at about the neutral point and grew fairly well over a range of pH 4.0–8.8. The germination of spores is very meager, slow and uncertain in pure water. Their germination is improved by the presence of N/50 and N/25 malic acid or acidified carbon food. Very few spores germinate and cause infection during December and January due to very low temperature. The spores, however, remain viable during freezing temperature and cause infection in February-March when the temperature varies between 20–27°C (Sattar and Hafiz 1952).

Transmission of Disease

Luthra and Bedi (1932) supported the view that the disease is seed-borne and suggested the use of seed grown in disease-free localities for the control of the disease. The importance of secondary infection in widespread attacks of the disease was recognized as early as 1930. It was pointed out by Sattar (1933) that the rainfall in summer and in the early growth phase resulted in luxuriant growth of chickpea and such a crop was most prone to attack. He pointed out that the parts of Punjab where blight was serious received on average more than 150 mm rainfall during the chickpea growing season and that blight appeared sporadically in parts with rainfall less than 87 mm during that period.

Further studies pointed out that blighted plant debris lying in the field on the surface of soil or threshing floor was a very important source of perpetuating the disease from year to year as the blight fungus could remain viable in chickpea plant debris for 2–3 years. Studies on dissemination of the fungus indicated that

conidia were not blown about by wind but were carried in rain water and rain splashing from diseased plants to healthy adjacent plants when strong winds accompanied rains. However, infected parts of the blighted plants become brittle, break off easily, and are carried by strong winds for some distance (Luthra *et al.* 1935).

The viability of the blight fungus in chickpea debris was studied by Luthra *et al.* (1935). They found that 1-year old debris carried virulent infection whereas the infective capacity of the 2-year old debris declined considerably and the 3-year old debris could cause little or no infection. It was not possible to isolate the fungus from blighted seed kept for 2 years in the laboratory. The blighted debris exposed to summer rain was rendered less harmful than the material lying in dry condition where the rainfall was 50 mm. A period of 60–70 days was sufficient to kill the fungus totally. The diseased debris buried in the soil at any depth from 5–15 cm was rendered harmless for subsequent chickpea crops, especially in the presence of high soil moisture (Sattar and Hafiz 1952).

Treatment of the infected chickpea seed with sulphur and copper carbonate could not completely control the disease. The fungus when grown in culture and kept in dried form retained its viability even after a period of 8 months (Sattar and Hafiz 1952).

Epidemiology of Chickpea Blight

Serious epidemics of blight have occurred in Pakistan and scientists have tried to determine a relationship between temperature and rainfall with the spread of the disease. Because weather data are scarce in the areas where chickpea blight usually occurs, it has not been possible yet to pinpoint the factors which trigger the spread of the disease in epidemic form. No regular studies have so far been made to elucidate the phenomenon.

Kausar (1960, 1968), Kausar and Ahmad (1967) and others have reported chickpea blight epidemics during the following years:

1928–29, 1929–30 and 1930–31	The crop badly suffered in Attock; the chickpea area was reduced drastically.
1936–37, 1937–38, 1938–39 and 1939–40	Almost complete failure of the crop in Attock and other adjoining districts.
1947–48, 1948–49, 1949–50, 1951–52 and 1953–54	Blight years in succession. The crop suffered to varying degrees in different years.
1956–57, 1957–58 and 1958–59	Severe blight epidemic in chickpea growing area
1972–73 and 1973–74*	Mild blight years
1975–76*	Mild blight years
1978–79 and 1979–80*	Severe epidemic of chickpea blight.
1980–81*	Up to 15% crop loss caused by chickpea blight; most of the chickpea area was diverted to wheat and oilseed crops.

* Annual Research reports, PL-480 Project on Gram Improvement from 1971–1981, University of Agriculture, Faisalabad.

Kausar (1960) discussed the reasons for the blight epidemic of 1956–57 and pointed out that the varieties which had remained resistant showed high susceptibility. C 612, a local cultivar, almost failed along with other selected and promising hybrids. Infection of blight started on early-sown crop in late November in Attock, Rawalpindi, Jhelum and most of the Thal area. However, dry weather during January-February-March arrested further spread of the disease. Early infection of the disease and the subsequent check in its development by dry weather resulted in the regrowth of most of the blighted plants, which is a characteristic feature of blight epiphytotics (Kausar 1958 a).

Blight broke out again in 1957–58 in epidemic form in Peshawar, Dera Ismail Khan, Rawalpindi, and in Thal. High rains during November and December 1957 provided suitable conditions for initial infection and later development of the disease (Kausar 1958 b).

The epidemic of 1958–59 was followed by a relatively wet summer which provided sufficient moisture, good germination and early growth of chickpea. Blight infection was initiated in the wake of heavy rains by mid-December and blight developed severely during January and February, which were months of high rainfall. Rains at the end of March and early April helped the development of infection on pods of surviving and dying plants and this resulted in high seed infection (Kausar 1960). Sattar and Hafiz (1952) reported that the critical period of rainfall from February to April had a lot of influence on the development of the disease. This period relates to the flowering and fruiting stages in chickpea. Disease was reported to appear in epidemic form in those years only when the rianfall during that period was about 150 mm or more.

Recently, I surveyed the chickpea growing area of the Punjab to assess the loss suffered by the crop due to blight. The intensity of attack was not as severe as during 1979–80. The primary infection of the crop had taken place in almost all locations, even in no-blight areas of Faisalabad, as a result of almost continuous cloudy weather, light drizzle and low temperatures in March. Almost dry weather after March 22 coupled with higher temperature did not let the infection increase in intensity. The result was that whereas highly susceptible cultivars were killed, C 727 – a susceptible type – escaped and did not show more than a few loci of primary infection.

The data on daily maximum temperature and rainfall for January, February, March and April for 1979, 1980 and 1981 are provided in Tables 1–4. It is apparent that severe blight epidemics of 1979 and 1980 were due to well spread and well spaced rainfall during the crucial months of Feburary and March. Intervening dry spells and high day temperatures reduce overall humidity to an extent that spores do not germinate. In this connection a continuous wet spell for 2–3 days with cloudy, overcast and light drizzle is much more conducive for the spread of the disease than a heavy shower on a single day followed by a dry spell.

Table 1
Maximum temperature and rainfall recorded at Faisalabad during January.

Date	Maximum temperature (°C)			Rainfall (mm)		
	1979	1980	1981	1979	1980	1981
1	18.0	13.0	22.0	Nil	14.4	Nil
2	20.0	15.0	23.0	Nil	Nil	Nil
3	18.5	15.0	21.0	Nil	Nil	16.2
4	18.0	17.0	18.0	Nil	Nil	Nil
5	21.5	18.0	13.0	Nil	Nil	2.6
6	21.0	19.0	17.0	Nil	Nil	Nil
7	21.5	19.0	17.0	Nil	Nil	Nil
8	18.5	20.0	19.0	Nil	Nil	Nil
9	20.5	21.0	19.0	Nil	Nil	Nil
10	22.0	20.0	19.0	Nil	Nil	Nil
11	24.0	21.0	19.0	Nil	Nil	Nil
12	22.5	18.0	17.0	Nil	Nil	Nil
13	19.5	19.0	21.0	Traces	Nil	Nil
14	14.0	20.0	20.0	7.6	Nil	Nil
15	15.0	21.0	20.0	Nil	Nil	Nil
16	12.5	20.0	22.0	Nil	Nil	Nil
17	13.5	19.0	21.0	Nil	Nil	Nil
18	17.5	20.0	21.0	Nil	Nil	Nil
19	18.0	18.0	22.0	Nil	Traces	Nil
20	20.0	18.0	24.0	Nil	Nil	Nil
21	19.5	17.0	22.0	Nil	Nil	Nil
22	17.0	19.0	24.0	Nil	Nil	Nil
23	19.5	21.0	21.0	Nil	Nil	Nil
24	18.0	22.0	18.0	Nil	Nil	18.4
25	21.0	24.0	16.0	Nil	Nil	Nil
26	18.0	22.0	15.0	Nil	Nil	Nil
27	17.5	19.0	15.0	Nil	2.2	Nil
28	17.0	20.0	18.0	Nil	Nil	Nil
29	16.5	21.0	16.0	16.5	Nil	Nil
30	12.0	20.0	18.0	9.5	Nil	Nil
31	16.0	22.0	21.0	Nil	Nil	Nil

Variability in the Fungus

Sattar and Hafiz (1952) have isolated about six cultural types, however, no difference in pathogenicity was observed. Two culture types depending on the color of mycelial growth were isolated by Inam (Annual Report, PL-480 Project, 1972–73) but no difference in virulence was observed.

Table 2
Maximum temperature and rainfall recorded at Faisalabad during February.

Date	Maximum temperature (°C)			Rainfall (mm)		
	1979	1980	1981	1979	1980	1981
1	15.5	23.0	17.0	Nil	Nil	Nil
2	18.0	22.0	18.0	Nil	Traces	Nil
3	19.0	18.0	20.0	Nil	0.2	Nil
4	20.0	18.0	15.0	Nil	Nil	Nil
5	18.0	16.0	15.0	Nil	Nil	6.4
6	18.0	16.0	16.0	Nil	Nil	Nil
7	17.5	19.0	18.0	Nil	Nil	Nil
8	19.0	21.0	20.0	Nil	Nil	Nil
9	21.0	22.0	22.0	Nil	Nil	Nil
10	22.0	23.0	23.0	Nil	Nil	Nil
11	20.0	22.0	24.0	Nil	Nil	Nil
12	21.0	24.0	24.0	Nil	Nil	Nil
13	19.5	23.0	24.0	Nil	Nil	Nil
14	21.0	24.0	23.0	Traces	Traces	Nil
15	22.0	24.0	23.0	Nil	Nil	Nil
16	16.5	22.0	24.0	7.8	Nil	Nil
17	17.0	23.0	24.0	5.6	Nil	Nil
18	20.0	25.0	26.0	Nil	Nil	Nil
19	21.0	25.0	27.0	74.6	Nil	Nil
20	15.0	23.0	27.0	7.5	Nil	Nil
21	17.0	22.0	27.0	Nil	Nil	Nil
22	17.0	27.0	27.0	Nil	Nil	Nil
23	17.0	26.0	27.0	Nil	Nil	Nil
24	20.0	27.0	27.0	Nil	Nil	Nil
25	18.0	27.0	28.0	2.2	Nil	Nil
26	21.0	28.0	24.0	Nil	Nil	Nil
27	21.0	28.0	24.0	Traces	Nil	Nil
28	20.0	27.0	24.0	Nil	Nil	Nil
29		26.0			Nil	

Basis of Resistance

The susceptibility of the resistant chickpea genotypes to early infection in 1957 in November-December was explained by the fact that plants of resistant cultivars like F_8 and F_{10} being less than 40 days old, were attacked severely as they had less malic acid in the early stage. The difference between the resistant and the susceptible varieties was visible after the plants had grown for 40 days (Hafiz

Table 3
Maximum temperature and rainfall recorded at Faisalabad during March.

Date	Maximum temperature (°C)			Rainfall (mm)		
	1979	1980	1981	1979	1980	1981
1	22.0	26.0	23.0	Nil	Nil	Nil
2	19.0	27.0	22.0	4.2	Nil	Nil
3	15.5	23.0	25.0	2.2	Traces	Nil
4	19.5	15.0	27.0	4.2	2.8	Nil
5	19.0	21.0	28.0	4.6	12.9	Nil
6	18.5	21.0	28.0	6.4	Nil	3.4
7	18.0	22.0	25.0	Nil	Nil	Nil
8	17.0	21.0	24.0	Traces	Nil	Nil
9	15.5	22.0	27.0	Nil	Nil	Nil
10	18.0	22.0	28.0	Nil	Nil	5.3
11	21.0	23.0	22.0	Nil	Nil	Nil
12	25.0	24.0	25.0	Nil	Nil	Nil
13	26.0	23.0	25.0	Nil	Nil	Nil
14	25.0	26.0	24.0	Nil	Nil	Nil
15	26.0	27.0	16.0	Nil	Nil	11.4
16	26.0	28.0	22.0	Nil	1.6	Nil
17	23.5	28.0	24.0	20.0	Nil	Nil
18	22.0	29.0	27.0	Nil	4.6	Nil
19	24.0	26.0	28.0	Nil	Nil	Nil
20	27.0	26.0	26.0	Nil	Nil	13.6
21	28.5	29.0	19.0	Nil	Nil	45.8
22	28.0	27.0	20.0	Nil	2.2	Nil
23	28.5	27.0	22.0	Nil	Nil	Nil
24	29.0	25.0	26.0	Nil	Nil	Nil
25	29.0	28.0	29.0	Nil	Nil	Nil
26	31.0	29.0	29.0	Nil	Nil	Nil
27	31.0	30.0	30.0	Nil	Nil	Nil
28	31.5	31.0	32.0	Nil	Nil	Nil
29	29.0	27.0	31.0	Nil	4.8	Nil
30	27.0	21.0	32.0	Nil	3.8	Traces
31	27.5	27.0	29.0	Nil	Nil	Nil

and Ashraf 1957). However, it was shown by Sattar (1933) that chickpea plants increased in susceptibility with age and plants were most susceptible at the flowering and fruiting stages. The present studies carried out in the chickpea project at Faisalabad, however, have shown that the resistance of some cultivars like AUG 480 was inherent and that young seedlings (up to 1 month) showed comparatively higher resistance than susceptible cultivars like C 727 (Aslam *et al.* 1981).

Table 4
Maximum temperature and rainfall recorded at Faisalabad during April.

Date	Maximum temperature (°C)			Rainfall (mm)		
	1979	1980	1981	1979	1980	1981
1	29.0	30.0	28.0	Nil	Nil	Nil
2	26.5	32.0	31.0	Nil	Nil	Nil
3	29.5	31.0	27.0	Traces	8.4	Nil
4	26.5	28.0	29.0	17.4	Nil	Nil
5	25.5	32.0	29.0	Nil	Nil	Nil
6	30.0	34.0	31.0	Nil	Nil	Nil
7	32.0	32.0	33.0	Nil	Nil	Nil
8	33.0	34.0	32.0	Nil	Nil	Nil
9	34.5	36.0	34.0	Nil	Nil	Nil
10	35.0	37.0	36.0	Nil	Nil	Nil
11	35.0	37.0	38.0	Nil	Nil	Nil
12	37.0	33.0	39.0	Nil	7.2	Nil
13	37.5	31.0	39.0	Nil	Nil	Nil
14	35.5	33.0	41.0	Nil	Nil	Nil
15	33.0	35.0	41.0	1.4	Nil	Nil
16	29.0	37.0	38.0	Nil	Nil	Nil
17	32.5	39.0	38.0	Nil	Nil	Nil
18	32.5	41.0	39.0	Nil	Nil	Nil
19	35.5	40.0	41.0	Nil	Nil	Nil
20	32.5	41.0	41.0	Nil	Nil	Nil
21	35.0	38.0	39.0	Nil	Nil	Nil
22	37.0	39.0	34.0	Nil	Nil	Nil
23	38.5	35.0	36.0	Nil	Nil	Nil
24	41.0	37.0	37.0	Nil	Nil	Nil
25	42.0	41.0	38.0	Nil	Nil	Nil
26	42.0	42.0	41.0	Nil	Nil	Nil
27	41.5	43.0	40.0	Nil	Nil	Nil
28	44.0	43.0		Nil	Nil	Nil
29	41.0	41.0		Nil	Nil	Nil
30	39.0	42.0		Nil	Nil	Nil

References

AHMAD, MUKHTAR. 1959. An analysis of factors underlying parasitism of *Ascochyta rabiei* and *Ascochyta pisi*. M.Sc. (Agri.) Thesis, University of the Punjab.

ASLAM,M., KHAN, A. and KHAN, I. 1981. Annual research reports of PL 480 project on gram. 1978–79 to 1980–81. University of Agriculture, Faisalabad.

BUTLER, E.J. 1918. Fungi and Diseases in Plants. Thacker Spink & Co. Calcutta, India. pp 244–251.

HAFIZ, A. and ASHRAF, M.1957. Association of morphological characters in gram plants with blight reaction. Agric. Pak. 8:1–4.

JONES, L.K. 1927. The relation of *Mycosphaerella pinodes* to Ascochyta blight of pea. Phytopathology 17:44.

KAUSAR, A.G. 1958a. Annual report of Plant Pathologist, Agricultural College and Research Institute, Lyallpur for the year ending 30th June, 1958.

KAUSAR, A.G. 1958b. Gram blight situation during 1957–1958. Abst. Pak. Assoc. Adv. Sci. Tenth Conference Biol. Sect.

KAUSAR, A.G. 1960. Gram blight situation during 1958–1959. Abst. Pak. Assoc. Adv. Sci. 12th Conf. Biol. Sect.

KAUSAR, A.G. 1968. Performance of blight resistant gram selections in wilt nursery and at six locations. Pakistan Agri. Sci. 5:264–273.

KAUSAR, A.G. and AHMAD, R. 1967. Reaction of gram selection to blight during recent epiphytotics. Pakistan Agri. Sci. 4:108–120.

LUTHRA, J.C. 1929. Annual report of the Associate Professor of Botany, Punjab Agricultural College, Lyallpur for the year ending June, 1928. *In* Report on the Operations of the Department of Agriculture for the year ending 30th June, 1928, Vol. I, Pt. II, Govt. Print. Press, Lahore.

LUTHRA, J.C. and BEDI, K.S. 1932. Some preliminary studies on gram blight with reference to its cause and modes of perpetuation. Indian J. Agric. Sci. 2:499–515.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1935. Life history of gram blight, *Ascochyta rabiei* (Pass). Lab. *Phyllosticta rabiei* (Pass). Trot. on gram (*Cicer arietinum* L.) and its control in the Punjab. Agric. Livestock in India 5:489–498.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1943. Further studies on the control of gram blight. Indian Fmg. 4:413–416.

SATTAR, A. 1933. On the occurrence, perpetuation and control of gram (*Cicer arietinum* L.) blight casued by *Ascochyta rabiei* (Pass.) Labrousse, with special reference to Indian conditions. Annals App. Biol. 20:612–632.

SATTAR, A. and HAFIZ, A. 1952. Research on plant diseases of the Punjab. Sci. Monograph I. Assoc. for Adv. of Sci. University Institute of Chemistry, Lahore.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

The Status of Chickpea Production and Research in Morocco

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Importance and Distribution

The food legume growing area of Morocco is about 520,000 hectares. The main pulse species are broad beans (*Vicia faba*), peas (*Pisum sativum*), chickpea (*Cicer arietinum*), lentils (*Lens esculenta*), dry beans (*Phaseolus vulgaris*), groundnut (*Araachis hypogaea*) and vigna (*Vigna sinensis*).

The chickpea with 85,000 ha is grown in the northern provinces around Meknes and the Sidi Kacem region (Fig. 1) with high rainfall during the spring season. More to the south, chickpea is cultivated in deep soil depressions.

The bioclimate of these zones varies from semi-arid with temperate winter to subhumid with more than 60 days of rainfall per year totalling 400–600 mm (Ionesco 1965). These zones correspond with the latest colonized areas which are characterized by large farms where mechanization is relativly advanced, but also where population pressure is the highest because of the labor demand of this crop.

Chickpea is cultivated as a spring crop in Morocco. In general, sowing is carried out from January to April. Seeding is often done by hand, as well as mechanically. Harvest is between June and August.

It is appropriate to mention the role of spring chickpea in the farming system: in effect this crop allows farmers to cultivate land during the spring season when the rainfall during the winter is either excessive or very late; cereals suffer from this situation. This is especially true in heavy soil where chickpea is considered as a replacement crop. It is a delicate crop because of its susceptibility to waterlogging or water stress, particularly in these soils.

Chickpea contributes to soil nitrogen reserves and can yield satisfactorily without expensive nitrogen fertilizer inputs. However, it may also draw out the

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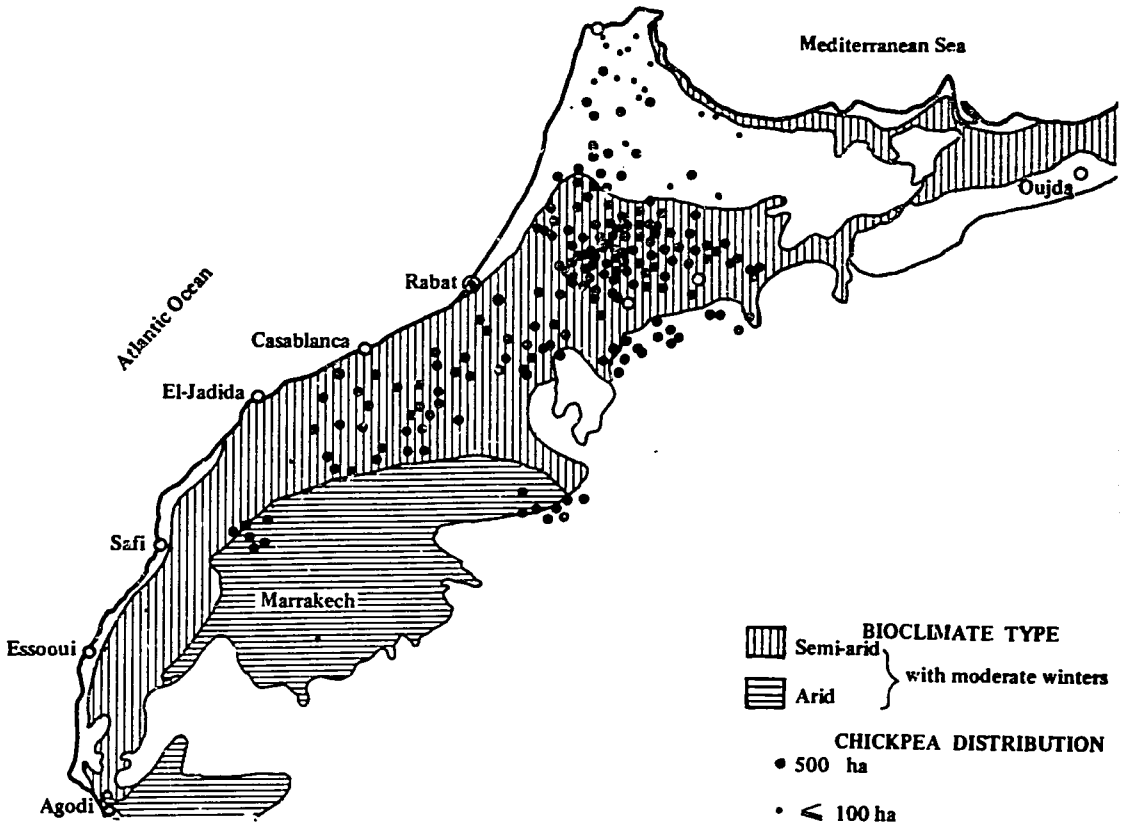

Figure 1
Geographical distribution of chickpea cultivation in northern Morocco in relation to the climatological conditions.

soil moisture and therefore it is a less appreciated legume crop in rotation systems.

Production and Uses

Kabuli type with salmon white testa color and large or medium seeds is cultivated in Morocco. The price depends essentially on the seed size. Chickpea is a remunerative crop; its local market value and yield approaches that of cereals and the export of about 40–50% of the total production brings important foreign exchange income to Morocco.

Human consumption is relatively low; it increases during Ramadan. According to the 1971–72 survey the local consumption of dry pulses would be 5 kg/person per year (Bonnenfant 1975). Experiments conducted with the cooperation of UNICEF on children's food, based on cereals and chickpea flour, have given promising results.

The average annual production is about 64,000 tonnes with important fluctuations between years (Table 1).

Yield does not seem to have increased significantly in the last decade. Compared with other legumes, yield is relatively low. Climatic and parasitic conditions and lack of certified seeds are largely responsible for this situation. Recently, a program of seed production of promising cultivars has been initiated by the Multiplication and Control of Seed and Plants Service (SCMSP).

Seed commmercialization is normally insured by SONACOS, the National Society of Seed Commercialization. However, there may be problems associated with increasing prices demanded for improved seeds. It is appropriate to mention the strenuous efforts of the government for seed price subsidies.

Table 1
Area, yield, production and export of chickpea, Morocco.

	1973	1974	1975	1976	1977	1978	1979	1980	Mean
Area (1000 ha)	84.1	158.1	98.5	99.6	42.4	67.9	62.3	65.5	84.8
Yield (q/ha)	9.4	10.3	6.1	5.1	2.6	5.4	10.3	6.8	7.0
Prod. (1000 q)	788.6	1637.9	608.3	510.5	109.7	366.7	641.7	445.6	638.6
Export (1000 q)	375.4	346.1	348.6	179.7	55.9	276.7			263.8

Source: DAE – ONICL.
q =100 kg.

Pests and Diseases

Chickpea is liable to attack by several pests and fungal diseases. The most important disease in Morocco is blight caused by *Aschochyta rabiei*. Blight is present in all chickpea areas. In 1971 the estimated loss was about 730,000 q, equivalent to more than US $10 million and the national average yield was only 0.2 q/ha (Janati and Schluter 1977; Boorsma 1978).

Foliar sprays with dithiocarbamates (maneb, zineb and mancozeb) at the rate of 800 g a.i./ha and seed treatment at the rate of 800 g a.i./q gave satisfactory results (Janati and Schluter 1977).

Other diseases recorded in Morocco are *Fusarium* spp., *Verticillum* sp. *Corticium solani*, *Uromyces ciceri-arietinum*, *Didymella rabiei* and *Mycosphaerella tassiana* (Rieuf 1971).

The common pests are *Liriomyzya cicerina* R. and *Heliothis armigera* H. Other pests recorded but of unknown economic importance are *Bruchus pisurum* L, *Agrotis ypsilon* R, *Macrosiphum pisi* J, *Spodoptera exigua* and *Ilena cana* (Fichier enthomologie).

One virus, mainly, pea leaf roll virus, has been identified.

Chickpea Research

Germplasm Collection

A research breeding program commenced in 1943 with emphasis on assembling a germplasm collection through (a) introduction, (b) selection within the local population, and (c) mutation. The biometrical and phenological characters of Morocco germplasm are shown in Table 2.

Selection among and within the germplasm collection provided the first promising kabuli type cultivars. Actually, lines Pch 46, Pch 30, Pch 37 and Pch 34 are multiplied by SCMSP.

The present collection is being classified for all readily distinguishable characteristics. Details of the first preliminary screening for blight resistance is shown in Table 3.

International Cooperation

The FAO International Program of Horizontal Resistance to crop pests and diseases in Morocco concerning chickpea commenced in 1976. The main objectives of this program are the development of adequate screening methods for disease resistance and the establishment of breeding strategy on horizontal resistance to ascochyta blight (Boorsma 1978).

Since 1978 a wide program of cooperation has been developed with ICARDA, especially in regard to the improvement of germplasm disease resistance for

Table 2
Characteristics of chickpea lines in Moroccan germplasm.

Characters	No. of samples	Mean	SD
Leaf Characters			
Leaflet characters	211	13.4	± 0.9
Leaf length (mm)	153	65.4	± 6.0
Leaflet length (mm)	73	16.0	± 2.9
Leaflet width (mm)	75	8.0	± 1.9
Phenological characters			
Days to emergence	1025	12.7	
Days to tillering	1297	16.8	± 1.4
Days to flowering	1222	64.4	± 4.1
Flowering period (days)	658	32.4	± 4.0
Days to maturation	1310	123.0	± 4.3
Yield components			
Plant height (cm)	728	50.6	± 6.5
Pods no./plant	.563	65.1	±19.6
Total branches (Pr +Sd)	735	8.6	± 1.6
100-seed weight (g)	1124	38.0	±12.0
Yield (q/ha)	903	16.27	± 3.98
Nutritional characters			
Protein (%DM)	396	22.04	± 1.24
Calcium (%DM)	50	0.174	± 0.027

Pr = primary; Sd = secondary; DM = dry matter; SD= standard deviation.

Table 3
Preliminary screening for ascochyta blight resistance of 169 chickpea lines.

Seed types	Blight Score*					Total lines	Promising lines
	1	2	3	4	5		
Kabuli	0	0	11	43	54	108	Pch 129, 120, 90, 46
Desi	2	1	8	13	8	32	Pch 217, 15, 1282, 1380
Intermediate	1	3	6	10	9	29	Pch 128, 70, 100, 134

* 1 = resistant, 5 = susceptible.

further crosses, screening early segregating populations of relevant crosses and the development of winter chickpea cultivars.

Objectives of Current Research

The specific objectives of the Moroccan breeding program are (1) the improvement of kabuli, large-seeded, high-yielding, early-maturing, spring cultivars, (2)

the development of disease resistance (especially blight and wilt), (3) the development of winter-adapted cultivars and the study of agronomic aspects, (4) biometrical studies and cultivar selection for mechanical harvesting, and (5) the improvement and diversification of chickpea uses.

Winter Chickpea

The yield in Moroccan rainfed conditions depends largely on the amount of rainfall, particularly between February and May (Table 4). However, yield also depends on blight incidence, e.g., in 1970–71 the national average yield was 0.2 q/ha (Janati and Schluter 1977).

Winter chickpea seems to be a solution to both problems because it increases the yield potential and it may avoid ascochyta blight attack because only resistant cultivars are being introduced for winter sowing.

Table 4
Chickpea yield, precipitation during February–May and annual rainfall, during the last 7 years in the Fes region, which represents 25–30% of total chickpea area in Morocco.

	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
Yield (q/ha)	8.4	8.6	7	4.9	1.9	3.5
Feb–May precipitation (mm)	269	336	322	251	139	290
Annual precipitation (mm)	666	553	418	379	620	540

Source: Statistiques agricoles du Maroc (DAE).

The primary yield trials on winter chickpea cultivars have been encouraging (Table 5). Winter chickpea offers a great possibility for improving productivity, but from a farming system point of view more work needs to be done. A number of questions have to be analyzed in detail, namely:

1. The role of chickpea in the farming system, taking into account the importance of spring chickpea as a replacement crop, and also the need for intensification of land use in favorable areas. However, the development of an early-maturing winter chickpea is more profitable and offers the possibility of cultivating summer crops. Winter chickpea could be more interesting in arid zones and offers the possibility of extending the cultivation area.

Table 5
Results of a trial on winter chickpea cultivars at Douyet – Fes (lat. 34° North, long 5°), 1979–80.

Cultivars	Origin	Blight incidence*	Yield (q/ha)
ILC 249	USA	2.3	39.68
ILC 482	Turkey	2.0	39.54
Pch 128	Morocco	2.7	35.31
ILC 3279	USSR	1.0	34.31
Pch 129	Morocco	3.0	32.75
ILC 215	USA	1.7	31.08
ILC 202	USSR	1.0	30.35
ILC 195	USSR	2.0	30.12
ILC 190	USSR	3.0	30.00
Pch 42	Morocco	3.5	29.79
Pch 34	Morocco	3.2	22.29
Pch 25	Morocco	4.0	5.07
Pch 20	Morocco	5.0	4.97
Pch 75	Morocco	5.0	0.88
Diff. of Dunett (0.01)			8.17

* 1–5 scale: 1 = resistant, 5 = susceptible.

2. The economic and social role within this system should be considered for both spring and winter chickpea, as well as their impacts on rotation systems.
3. As a consequence of chickpea introduction into the winter crop system, land use, agricultural practices and production factor uses will be strongly influenced by this crop.
4. Agronomic impacts should be studied, particularly the impact of winter chickpea on soil-moisture level, nitrogen fixation and the risks of waterlogging in clay soils where chickpea is normally cultivated as a spring crop.
5. From the disease point of view, other parasites might gain importance. A serious *Fusarium* attack (23 lines from 25 have been completely destroyed) has already been observed in experiments on winter chickpea on clay soils. Bioecological studies and incidence of major parasites should be included in this topic.
6. Cold tolerance of kabuli type should be developed. At INRA, about 40 lines collected from India, US and Morocco are being studied for this purpose. Desi and intermediate types have shown better adaptation to cold winter than the large-seeded kabuli type. Further results will be developed on this aspect.

In view of these considerations, on-farm trials will be started immediately to get farmers' reaction. The farmers will be associated in this work so that the

social and technical problems may be identified and an appropriate improvement strategy developed.

References

BONNENFANT, C. PAPY. 1975. Cultures maraicheres et industrielles, epices et legumineuses ouvrage public par Atlas du Maroc.

BOORSMA. 1978. Rapport IPHIR station centrales des legumineuses alimentaires, INRA.

DAE-ONICL. Documentation de l'office National des Cereales et des Legumineuses, ONICL.

FICHIER ENTHOMOLOGIE. Section Zoologie, INRA.

IONESCO, T. 1965. Considerations bioclimatiques et phyto ecologique sur les zones arides au Maroc cahier Rech. Agro. No. 19 carte No. 18.

JANATI and SCHLUTER, A. 1977. Lutte contre l'anthracnose du pois-chiche.

RIEUF, P. 1971. Parasites et saprophytes des plantes au Maroc cahier Rech. Agro. No. 29 et 30.

Statistiques Agricoles/Division des Affaires Economiques de 1972 a 1980.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4-7 May 1981, Aleppo, Syria

Chickpea Improvement in Tunisia

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Agriculture is the main source of the Tunisian economy. Grain legumes cover ony 6% of the total area cultivated with food grains in Tunisia. Faba beans and chickpeas, which are grown as rainfed crops, are the dominant grain legumes (86%).

Chickpea culture covers around 23,000 ha especially in the northern part of the country. Two areas are important for chickpea production: the primary area includes Bizerte, Beja, and Jendouba; the secondary area where production is less important includes Kef, Siliana, Tunis, and Nabeul. The chickpea area and production vary from year to year (Table 1) depending on the amount and distribution of rainfall during the whole season. Generally, total rainfall in these regions varies from 400 to 800 mm.

Major Factors Limiting Increased Production

Diseases, rainfall, and seed production capacity are the main problems.

Diseases: During the rainy springs, most of the damage caused is due to ascochyta blight; however, during the dry springs fusarium wilt is predominant.

Rainfall: Its distribution prevents the early sowing of chickpeas.

Seeds and Cultivars: There are no improved Tunisian cultivars; local landraces such as Amdoun are seeded, which could be considered a limiting factor of the production because these cultivars are low yielding.

Production Technology

Crop is commonly grown in a three- or four-course rotation system, for example forage, chickpea, wheat; and sugar beet, wheat, forage, chickpea, respectively.

Table 1
Area, production, and yield of chickpea in Tunisia.

Year	Area (ha)	Production (t)	Yield (kg/ha)
1974	19,940	17,620	880
1975	20,565	18,387	900
1976	19,799	19,148	970
1977	21,700	10,900	502
1978	15,905	18,749	724
1979	32,550	21,830	671
1980	34,330	27,670	806

The effectiveness of these systems has been demonstrated in many areas where weed control has been established.

The Technical Division of the Office of Cereals has conducted some field trials on cultural practices of food legumes. The seeding rate varies from 80–100 kg/ha. Planting extends from early March to mid-April. Only phosphate fertilizer is applied. Depending on the region, harvest is from the end of June to the end of July.

The major diseases observed have been chocolate spot (*Botrytis* sp.), blight (*Ascochyta* sp.), wilt (*Fusarium* sp.) and rust (*Uromyces* sp.). Ascochyta blight losses may reduce yields by 40%. The most important insect pest is the leaf weevil.

Most farmers hand weed chickpea fields, but some use a combination of treflan (preemergence) and gesatop (postemergence) herbicides to get satisfactory weed control.

Chickpea Winter Trials

Since 1977 a program of introduction and adaptation of new cultivars has been operating in collaboration with ICARDA. The goal is to select cultivars with high yield and stable resistance to major diseases.

In the winter of 1980-81, the Chickpea International Yield Trial-Winter (CIYT-W) was sown in the north at Mateur, Krib and Zaghouan. One of the three trials of winter chickpea was lost, probably due to cold damage.

Conclusion

Chickpea in Tunisia has not received enough attention in terms of practical research on cultivaral improvement. New high-yielding and stable cultivars are needed. Efforts towards these main objectives should be expanded by introducing germplasm from ICARDA.

Discussion

J.B. Smithson
How important is *Fusarium* wilt?

S.B. Hamadi
Fusarium wilt is important when ascochyta blight is not prevalent.

M.V. Reddy
Last year when we visited Beja Agricultural Experimental Station in Tunisia, we observed incidence of wilt (*Fusarium oxysporum*) in the experimental fields. But no incidence of wilt was observed in farmers' fields.

Y.L. Nene
Why do you call *Botrytis* disease as chocolate spot? Why not use the common name botrytis gray mold?

S.B. Hamadi
A mistake was made, as *Botrytis* is known to occur on faba beans and is called chocolate spot.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Ascochyta Blight and Chickpea Production in India

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Area, Production and Distribution

The total world area under chickpea is around 10.3 million hectares of which about 7.9 million hectares are in India (Table 1). Thus India accounts for about

Table 1
Area (x 000 ha), production (x 000 tonnes) and yield (kg/ha) of chickpea in the world, Asia and India.

		1965–66	1975–76	1978–79
World	Area	10464	10610	10364
	Prod.	5639	7319	7405
	Yield	539	690	714
Asia	Area	9435	9917	9667
	Prod.	4999	6895	6859
	Yield	530	695	709
India	Area	7994	8320	7984
	Prod.	4206	5880	5835
	Yield	526	707	731
India as percent of Asia	Area	84.7	83.9	81.4
	Prod.	84.1	85.3	85.1
India as percent cent of World	Area	76.4	78.4	77.0
	Prod.	74.6	80.3	78.8

77% of the total area under chickpea in the world. The area in India has,

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however, remained almost static in the last 13 years. The yield per hectare in that period increased from 526 kg/ha to 731 kg/ha, an increase of 39% while total production rose from 4206 to 5835 thousand tonnes. A comparison of the area, production and yield of the year 1978-79 in different states of India with the corresponding figures of the base 1964-66 shows that the area under chickpea increased in the states of Madhya Pradesh, Rajasthan and Maharashtra. A significant decrease occurred in Uttar Pradesh, Punjab, Bihar and West Bengal with an overall net decrease of 480 thousand hectares (Table 2).

Table 2
Comparison of area, production and yield of chickpea in different states of India.

States	Area (000 ha)			Production (000 tonnes)			Yield (kg/ha)		
	1964 -66	1978 -79	Dif-ference	1964 -66	1978 -79	Dif-ference	1964 -66	1978 -79	Dif-ference
Madhya Pradesh	1518	1867	+349	843	1107	+ 264	555	593	+ 38
Rajasthan	1239	1846	+607	564	1587	+1023	455	860	+405
Uttar Pradesh	2546	1647	-899	1909	1264	- 645	750	767	+ 17
Haryana	1122	1120	- 2	687	1037	+ 350	612	926	+314
Punjab	674	357	-317	519	284	- 235	770	796	+ 26
Maharashtra	358	442	+ 82	101	157	+ 56	282	355	+ 73
Bihar	460	229	-231	239	121	- 118	520	529	+ 9
Karnatka	132	163	+ 31	39	74	+ 35	295	454	+159
West Bengal	147	89	- 58	94	65	- 29	639	730	+ 91
Gujrat	72	70	- 2	39	59	+ 20	542	843	+301
Andra Pradesh	75	69	- 6	21	19	- 2	280	302	+ 22
Other remaining states	121	85	- 36	27	61	+ 34	223	717	+494
India	8464	7984	-480	5082	5835	+ 870	587	731	+144

Source: Statistical Abstracts, Punjab and Agricultural Situation in India.

The overall production increased by 870 thousand tonnes during the corresponding period. The average yield of chickpea increased in all states, but the increase was most marked in Rajasthan, Haryana, Gujarat and Karnataka. The decrease in area in Uttar Pradesh, Punjab, Bihar and West Bengal was due mainly to the diversion of traditional chickpea areas to high-yielding wheat varieties.

Major Factors Limiting Increased Production

1. Chickpea is grown mostly on poor soils under nonirrigated conditions and hardly 10% of the area is irrigated.
2. Seasonal constraint: Most of the chickpea crop depends on the conserved moisture of monsoon rains. Rainfall in the country is unpredictable and erratic, so the crop suffers sometimes due to moisture stress, and excessive moisture in other years.
3. It is highly risky and unassured crop because of high incidence of diseases and pests like wilt, blight, stem rot, foot rot and *Botrytis* and pod borers.
4. A lack of suitable genotypes responsive to increased use of irrigation and fertilizers.
5. Non-availability of seed of high-yielding cultivars.
6. Economics of production of chickpea under maximum input conditions does not compare very favorably with the competing wheat crop.
7. Lack of efficient *Rhizobium* strains for effective symbiosis and competition with native flora where chickpea is cultivated year after year.

Cultural Practices

Chickpea is grown in the winter season in India. Sowings start in October. The growing season temperatures are higher in South India as compared with North India, thus the growing period in southern India is comparatively shorter.

Land Preparation

Generally farmers give insufficient attention to soil moisture conservation during the monsoon season. With the increase in intensity of cropping, some area of chickpea is also grown after sorghum, maize and pearl millet. The seed bed preparation in this cropping system is done either after the rain is received or after an irrigation, where facilities are available. The crop is also grown after paddy on residual moisture. It is generally grown as a sole crop under rainfed conditions on the sandy and sandy-loam soils in northern India or on deep black soils in the South. Sometimes it is also grown mixed with wheat, barley, rape-mustard, rocket (*Eruca sativa*) and sorghum. This mixed cropping is a sort of insurance in rainfed agriculture against extremes of environmental conditions which can cause complete crop loss. It also helps in reducing losses due to diseases.

Seed Source

The farmers mostly use the local seed grown on their own fields. But some farmers also procure certified seed of the approved cultivars from the Regional

Agricultural Universities and seed agencies like the State Corporations, and National Seeds Corporation, etc.

Sowing Time and Seed Rate

The best sowing time is middle of October to the middle of November depending upon the soil and temperature conditions. Generally, a seed rate of 45 kg/ha is used for desi types having a 100-seed weight around 13 g. The seed rate is increased proportionately for types with larger seeds. The average seed rate for the kabuli types is around 85 kg/ha because these types have comparatively larger seeds as well as a low emergence percentage.

Sowing Methods and Fertilizer Use

The seed is drilled with the help of a heavy desi (country) plow having an iron or wooden tube tied to it for placement of seed at the proper depth. Generally the seed is sown at a depth of about 10 cm and the row-to-row distance is mostly kept at 30 cm, but in heavy soils the row-to-row spacings are increased to 40–45 cm. Most of the farmers do not use any fertilizer. However, phosphatic fertilizers at 20–30 kg P_2O_5/ha enhance the yield in soils having low available phosphorus. A A starter dose of 15 kg N/ha helps in establishment of the crop particularly in soils of poor fertility.

Pests, Diseases and Weeds

The pod borer (*Heliothis armigera*) is the most important pest of this crop and in some years it may cause enormous losses. Cutworm (*Agrotis* spp.) is a pest in initial growth stages.

Wilt caused by *Fusarium oxysporum* f. sp. *ciceri* and blight incited by *Ascochyta rabiei* are major diseases. But *Rhizoctonia solani*, *Rhizoctonia bataticola*, *Operculella padwickii*, *Sclerotium rolfsii*, *Sclerotinia sclerotiorum* are other soil-borne fungi which cause root rot, dry root rot, foot blight, collar rot and stem rot, respectively. The two other foliar diseases botrytis gray mold (*Botrytis cinerea*) and stemphylium blight (*Stemphylium sarciniforme*) may sometime take a heavy toll of the crop. The rust (*Uromyces ciceris-arietini*) is not a major problem in most of the areas in India. Phyllody and stunt are serious problems in some areas.

The incidence of wilt can be reduced if the crop is sown deep and at the optimum time when temperatures are not too high, the condition which favors buildup of the soil-borne fungi at a rapid rate. No workable control measures are available against blight. Development of resistant cultivars is the most effective way to combat the disease.

Weeds reduce the yield of chickpea considerably, if not properly managed by

hand hoeing. During the early growth phase, the crop grows very slowly and the weeds which grow fast deplete soil moisture and nutrients. The important weeds in the crop are *Chenopodium album*, *Asphodelus tunnifolius*, *Argemone mexicana*, *Convolvulus arvense* and *Trigonella polycerrata*.

Harvesting and Threshing Methods

The crop is harvested manually with sickle when most of the pods and leaves turn brown. The crop is stacked in the fields till it becomes dry. Threshing is done either by trampling the crop with bullocks or by running a stone roller over it. The winnowing is done to separate the grain from the straw.

Ascochyta Blight Research

This disease is known by various names such as gram blight, ascochytosis, anthracnose, rabia or scorch of chickpea. The causal organism of chickpea blight was first named *Zythia rabiei* by Passerini (1867). The other synonyms of the fungus are *Mycosphaerella rabiei*, *Phyllosticta rabiei*, *Phoma rabiei* and *Ascochyta rabiei*, the last name being the most accepted.

Inheritance of Resistance to Ascochyta Blight

Hafiz and Ashraf (1953) crossed F8 and F10 (two resistant types) to two susceptible Punjab types Pb7 and C7; Vir *et al.* (1975) crossed 1–13 (resistant) and Pb7, NP58 and RS10 (susceptible type) including the reciprocals. In all the cases, the F1s were resistant and the F2s gave fit to 3 resistant:1 susceptible, indicating monogenic difference between the lines used in the crosses and resistance being dominant.

Review of Past Research on Ascochyta Blight

Many workers (Luthra and Bedi 1932; Sattar 1933; and Luthra *et al.* 1935), have investigated the life history of blight and its control measures and have reported that the maximum, optimum and minimum temperatures for germination of spores and growth of the fungus were 32.5, 20, and below 10°C, respectively. The disease was carried from one season to the other by sowing infected seeds and by diseased plant debris which remain lying on the surface of the soil. They also reported that the disease spreads from plant to plant and field to field by secondary infection carried by spores and diseased parts of plants. The fungal spores are not blown by wind in dry weather. They recommended the use of disease-free seed, sanitation and a 2- to 3-year rotation for control of the disease.

Sattar (1933) observed that susceptibility of plants increased with age, being

greatest at flowering and fruiting stage; and suggested that for testing the resistance of genotypes to blight, inoculations should be made at flowering and fruiting stage, as otherwise the susceptible varieties may show a deceptive appearance of resistance.

Since the beginning of the present century including the prepartition period, there have been only a few reports of severe blight disease (Table 3).

Table 3
Reports on occurrence of severe blight disease in India (including the prepartition period).

Investigator	Year of occurrence	Area
Butler (1918)	1911	North-western Frontier Province (now in Pakistan)
Singh (1927)	1924–25 1925–26	Attock district of Punjab now in Pakistan)
Mitra (1936)	1933–34	IAR, Pusa (Bihar)
Dep. Agr. Punjab (1938)	1936–37	Attock district of Punjab (now in Pakistan)
Dep. Agr. United Provinces (1949)	1947–48	Central Station of Agricultural Institute, U.P.
Bedi and Athwal (1962)	1950–51	Whole of the Punjab
Bedi (1961)	1958–59	Whole of the Punjab
Sandhu (1972)	1965-66 1967–68	Whole of the Punjab
Personal observation	1980–81	Whole of the Punjab

Disease-Resistant Sources

Singh (1927) reported field resistance in Punjab No.7, Bhakkar, Isakhal and Mianwali cultivars, while heavy damage by blight was caused to late types Rajanpur, Alipur, Punjab No.23 and Khanewal during 1924–25 and 1925–26. Mitra (1936) reported that during the severe infection of chickpea blight at Pusa, Bihar during 1933–34, attack on types 48, 49, and 67 was moderate, type 68 was severely affected; on 18 lines the attack was slight, and on 34 only a trace of blight was present.

Luthra *et al.* (1941) studied 392 types, 187 collections received from the Bureau of Plant Industry, USDA, Washington, D.C., and 205 samples supplied by the Millet Botanist, Sirsa, India, for resistance to blight. None of the local entries possessed resistance to blight, however, three foreign types were highly resistant to the disease and their description is as under:

Pois Chiche 4F32 (F8): Yellow seed coat, rough surface, seeds 1.5 times heavier than Pb7 and late in maturity.

Pois Chiche No. 199 (F9): Dull white seed coat, smooth surface and seeds 1.5 times as heavy as Pb7. Pois Chiche No. 282 (F10): Black seed coat with slightly rough surface, seeds 2.25 times as heavy as those of Pb7.

Relative resistance of these types was F10>F8>F9. However, type F8 having high resistance to blight when distributed to farmers in 1940–41 was found highly susceptible to wilt in some areas. In the evolution of blight-resistant cultivars since then, F8 genes have been used:

Year of release	*Type*	*Pedigree*	*Remarks*
1944	C1234	Pb7 x F8	Became susceptible in 1950–51
1960	C235	1.P.58 x C1234	Became susceptible in 1967–68
1977	C543	C235 x C168	Showed a high degree of infection to blight in 1980–81

During severe infection in 1947–48 at the Central Station of the Agricultural Institute in U.P., three lines (99/21,21 and 142) showed some resistance. Aujla and Bedi (1967) found 11 lines, viz. 11/48–7, BN 3118, P36, Broach, GG Pedapuram, Attock 234, 337, 172–3, 436, 84 and 241/1 resistant to blight. Sandhu (1972) reported that out of 600 lines ony 11 survived the severe blight attack in 1967–68. These were Galban Gafnier, Galban, Negro, Brunra Scatdie and Albgatbai from Rumania; V138 from Mexico; E.C.12411 from USSR, and E.C.21628, EC26414, EC26435 and EC26446 from Israel. Grewal and Vir (1974) reported that selection P1528–1–1 from Morocco was found immune and I–13 (12–074–06625) from Israel was resistant to blight.

Physiological Races

Luthra *et al.* (1939) reported that five cultural forms of the fungus, pathogenic to chickpea, were biologically identical and thus Punjab had no physiological races. However, Aujla (1964) reported the presence of eleven distinct strains differing in their cultural characters as also in their pathogenic behavior in different chickpea lines. Further, Bedi and Aujla (1969) established the presence of physiological races in this fungus and suggested that to locate sources of resistance in blight, the breeding material may invariably be tested against all the physiological races prevalent in the area. Vir and Grewal (1974a) reported the existence of two distinct races and one biotype in their study of 268 isolates of *A. rabiei*.

Basis of Resistance

Kunzru and Sinha (1966) reported that an antibiotic principle which diffuses in the inoculation droplets during the course of interaction between *A. rabiei* and pod tissues plays some role in resistance. The antibiotic principle was given a status of phytoalexin and named 'Cicerin' and is composed of two phenolic compounds. Keen (1975) found that germinating seed of chickpea challenged with native microflora produced some phytoalexins, like other plant tissues.

Vir and Grewal (1974b,c; 1975a,b) studied in detail the biochemical basis of resistance by using resistant line I–13 and a susceptible type Pb7. Their work showed that the total phenolic contents were higher in leaves than stem. There was no significant difference in phenolic contents of resistant and susceptible cultivars before inoculation; however, after inoculation, the increase was more pronounced in the resistant cultivar than in the susceptible one (1974b). Peroxidase activity after inoculation was higher in the resistant cultivar as compared with the susceptible type (1974c). Higher free amino acid L-cystine (1975a), and higher catalase activity (1975b) in the resistant type were also found.

Control Measures

Sattar (1933) suggested disinfecting externally contaminated seed in 0.5% copper sulphate solution for 10 minutes and treating internally infected seed by presoaking in water at 20°C for 6 hr and then dipping it in hot water at 53°C for 15 minutes.

Chauhan and Singh (1966) reported that Aretan at 300 μg/ml and Ceresan wet at 2000 μg/ml gave 100% control of blight on chickpea. Vir and Grewal (1974d) reported that Captan at 1 kg per 400 liters of water was found effective when sprayed four times and Zineb was next in efficiency.

References

AUJLA, S.S. 1964. Study on eleven isolates of *Phyllosticta rabiei* (Pass. Trot.,) the causal agent of gram blight in the Punjab. Indian Phytopath. 17:83–87.

AUJLA, S.S. and BEDI, P.S. 1967. Relative reaction of different varieties of gram to blight disease incited by *Phyllosticta rabiei* (Pass.) Trot. in the Punjab. J. Res. Punjab agric. Univ. 4:214–216.

BEDI, K.S. 1961. Outbreak of gram blight in Punjab in 1958–59. Plant Prot. Bull. 12:24–25.

BEDI, K.S. and ATHWAL, D.C. 1962. C235 is the answer to blight. Indian Fmg. 12(9):20–22

BEDI, P.S. and AUJLA, S.S. 1969. Variability in *Phyllosticta rabiei* (Pass.) Trott., the incitant of blight disease of gram. J. Res. Punjab agric. Univ. 6:103–106.

BUTLER, E.J. 1918. Fungi and Diseases in Plants. Thacker Spink & Co. Calcutta, India. pp. 268–271.

CHAUHAN, L.S. and SINGH, B.K. 1966. Effect of fungicides on the growth of *Ascochyta rabiei*, causal organism of gram blight. Labdev J. Sci. Tech. 4:57–58.

DEP. AGR., PUNJAB 1938. Plant Diseases. Rep., 1936–37. pp. 52–586.

DEP. AGR., UNITED PROVINCES 1949. Annual Administrative Report for the year 1947-48. 89pp.

GREWAL, J.S. and VIR, S. 1974. Varietal resistance of gram to Ascochyta blight. Indian Phytopath. 27: 743-645.

HAFIZ, A. and ASHRAF, M. 1953. Studies on the inheritance of resistance to Mycosphaerella blight in gram. Phytopathology 43:580-581.

KEEN, N.T. 1975. The isolation of Phytoalexins from germinating seeds *Cicer arietinu*, *Vigna sinensis*, *Arachis hypogea*, and other plants. Phytopathology 65:91-92.

KUNZRU, R. and SINHA, S. 1966. 'Cicerin' a new phytoalexin associated with blight of gram . Pages 724-732 *in* Proceedings of the first International Symposium of Plant Pathology, Indian Phytopath. Soc., New Delhi.

LUTHRA, J.C. and BEDI, K.S. 1932. Some preliminary studies on gram blight with reference to its cause and made of perennation. Indian J. agric. Sci. 2:499-515.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1935. Life history of gram blight (*Ascochyta rabiei*) (Pass.) Lab. *Phyllosticta rabiei* (Pass.) Trot. on gram (*Cicer arietinum* L.) and its control in the Punjab. Agr. Live-Stk., India S:489-498.

LUTHRA, J.C., SATTAR A. and BEDI, K.S. 1939. Variation in *Ascochyta rabiei* (Pass.) Labr., the causal fungus of blight of gram (*Cicer arietinum* L.). Indian J. agric. Sci., 9:791-805.

LUTHRA, J.C., SATTAR, A. and BEDI, K.S. 1941. Determination of resistance to the blight disease *Mycosphaerella rabiei* Kovacevski-*Ascochyta rabiei* (Pass.) Lab. in gram types. Indian J. agric. Sci. 11:249-264.

MITRA, M. 1936. Report of the Imperial Mycologist., Sci. Rep. Agr. Res. Inst. Pusa, 1933-34:139-167.

PASSERINI, G. 1867. Common Soc. Critt. Ital. 2:435-476.

SANDHU, T.S. 1972. New sources of resistance to gram blight disease (*Ascochyta rabiei* Kovacevski). Madras agric. J. 59(1):41.

SATTAR, A. 1933. On the occurrence, perpetuation and control of gram (*Cicer arietinum*) blight caused by *Ascochyta rabiei* (Pass.) Labrousse, with special reference to Indian conditions. Ann. appl. Biol. 20:612-632.

SINGH, R.D. 1927. Report on the operations of the Dep. of Agr., Punjab for the year ending 30 June, 1926, Part II(1):145.

VIR, S. and GREWAL, J.S. 1974a. Physiologic specialization in Ascochyta rabiei, the causal organism of gram blight. Indian Phytopaht. 27:355-360.

VIR, S. and GREWAL, J.S. 1974b. Changes in phenolic content of gram plant induced by Ascochyta rabiei infection. Indian Phytopath. 27:524-526.

VIR, S. and GREWAL, J.S. 1974c. Peroxidase activity associated with Ascochyta blight of gram (*Cicer arietinum* L.). Phytopathologia Mediterranea 13:174-175.

VIR. S. and GREWAL, J.S. 1974d. Evaluation of fungicides for the control of gram blight. Indian Phytopath. 27:641-643.

VIR, S. and GREWAL, J.S. 1975a. Role of free amino acids in disease resistance to gram blight. Indian Phytopath. 28:206-208.

VIR. S. and GREWAL, J.S. 1975b. Change in catalase activity of gram plant induced by *Ascochyta rabiei* infection. Indian Phytopath. 28:223-225.

VIR, S., GREWAL, J.S. and GUPTA, V.P. 1975. Inheritance of resistance to *Ascochyta blight* in chickpea. Euphytica 24:209-311.

Discussion

M. Aslam

What is your feeling about the frequency of occurrence of ascochyta blight in Punjab (India)? Is the disease increasing there?

T.S. Sindhu

There was a severe epidemic of blight during 1967–68, but after that it has not been observed.

K.B. Singh

During 1967–68 the blight occurred in Punjab in a form that the farmers did not even harvest the crop. But in the subsequent years this disease was not even seen. So I feel that epidemiology is not fully understood and more needs to be known.

Y.L. Nene

I would like to say that there is no increase in the frequency of ascochyta blight epidemic in India. The disease is endemic in Gurdaspur, and depending upon weather conditions, it reaches epidemic proportions in certain years.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 198., Aleppo, Syria

Ascochyta Blight Situation of Chickpea in Ethiopia

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Ascochyta blight was not well known in Ethiopia until it was first observed around 1969 at Kulumsa, 175 km south of Addis Ababa. There was no known evidence whether the disease was introduced or indigenous to the country. Some pathologists assume that this disease might have come with seeds from the Middle East.

According to the Chilalo Agricultural Development Unit (CADU) 1969 report, chickpea cultivars DZ–10–10, Punjab 7, and C 217/3 were severely attacked by blight (*Ascochyta rabiei*) at Kulumsa. The disease appeared to be a serious problem on chickpeas planted particularly under moist conditions. Ascochyta leaf blight was also observed almost wherever chickpea was grown at Kulumsa and at a few other locations in the CADU project area. The yield of the chickpea trial was also reported to be low due to the heavy attack by ascochyta blight soon after planting. The only line not severely attacked was C 410 (CADU 1971).

Ascochyta blight was not observed during the 1971 and 1972 cropping seasons (CADU 1972, 1973) despite the fact that the disease was believed to be a major problem in chickpea around Kulumsa.

Regarding the presence of ascochyta blight in Ethiopia, if it is assumed to be an introduced disease, there is (1) the possibility that it came with seeds of cultivars Punjab 7, C 217/3 and C 410, or (2) since chickpea is not widely grown in Kulumsa and Arsi, it could have been present but not noticed by farmers long before CADU.

The same disease was observed by Dr. Gallagher (USAID researcher) at Debre Zeit in 1976–77 on small plots of chickpea planted in July on light soil. In 1977–78 Dr. Gallagher reported its occurrence at Debre Zeit (July planting), Arsi Negele (July planting), and at Mekele. In the chickpea national yield trial at these locations in 1978–79, the disease appeared to kill some susceptible culti-

vars. It was assumed that the disease was transported with the seeds from Debre Zeit. As a result of this, the pathologists from Institute of Agricultural Research (IAR) and Debre Zeit Research Center instructed the crop coordinator to discontinue the national yield trial of chickpea for 2 years in order to control the disease by crop rotation.

Now there is a general view not to plant any chickpea during the rainy season; there is also a general understanding not to create the environment that aggravates this disease. The national yield trial will begin again from 1981–82 cropping season.

References

CADU 1969. Report on Survey and Experiments, Crop Production Department. Public. No. 46:35.

CADU 1971. Report on Surveys and Experiments carried out in 1970 by Crop Production Department, Asela. Public. No. 63:51.

CADU 1972. Report on Surveys and Experiments carried out in 1971. Crop and Pasture Section, Asela, Public No. 80:64.

CADU 1973. Report on Surveys and Experiments carried out in 1972. Crop and Pasture Section, Asela, Public. No. 87:69.

Discussion

K.B. Singh

What is the status of ascochyta blight in your country when the crop is sown at normal time?

G. Bejiga

When it is planted at normal time there is no ascochyta blight. In fact, it is only a problem at the experiment stations. No ascochyta blight has been observed on farmers' fields.

M.V. Reddy

From the presentation it appears that ascochyta blight has existed in Ethiopia for several years and the belief that it has come through seed from other countries in the recent past does not seem to be correct. The discontinuation of work on chickpeas because of this problem does not appear to be the answer. Several resistant lines in desi type are now available and they can be tested and resistant ones can be selected for early planting so that the production can be increased.

G. Bejiga

If resistant lines are available we can use them. The sick plot developed for screening against root rot and wilt has become a sick plot for ascochyta blight as well. Therefore, it can be used.

Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas (Saxena, M.C. and Singh, K.B., eds.), ICARDA, 4–7 May 1981, Aleppo, Syria

Ascochyta Blight of Chickpeas in Spain

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Chickpea Area, Distribution and Major Limiting Factors

In 1978, chickpea was cultivated in Spain in the regions shown in Figure 1. It is interesting to compare this distribution with that in 1922 (Fig 2). The trends in area, production and yield since 1920 are indicated in Figure 3, which shows that the chickpea area is steadily decreasing in Spain. A similar pattern is offered by other pulses (*Lathyrus* sp., *Vicia* sp., field peas etc.) and some causes have been suggested to explain this fact:

1. This pattern is shown by the grain legumes used for animal feed. The massive soybean importations since the late fifties have provoked a lack of interest in such crops; all the animal feed industries are based on soybeans and not on traditional pulses.
2. During the same time, the economic situation has resulted in a big migration from rural areas to the cities. Chickpeas, like most of the pulses, were preferentially cultivated in rural poor areas, and they were among the first to be abandoned.
3. Yields have been traditionally very low (Fig. 3), so farmers do not get any substantial revenues from chickpeas. There are no selected cultivars and hence no recommended list for chickpeas in Spain.
4. Improvement in farming techniques has been generated by the work of good farmers themselves. Extensionists have forgotten chickpeas as with many other pulses and have concentrated on the big crops of the moment – soybean in the period 1960–70, sunflower since 1970, and sugar-beet according to the political conveniences, etc. Pulses have probably been the crops suffering most from a lack of adequate policy.
5. Once chickpea for human consumption reached high price (mainly the extra large types), there was one more constraint to increasing the cultivated area, i.e. importations from Mexico. Table 1 gives an idea of the importance of

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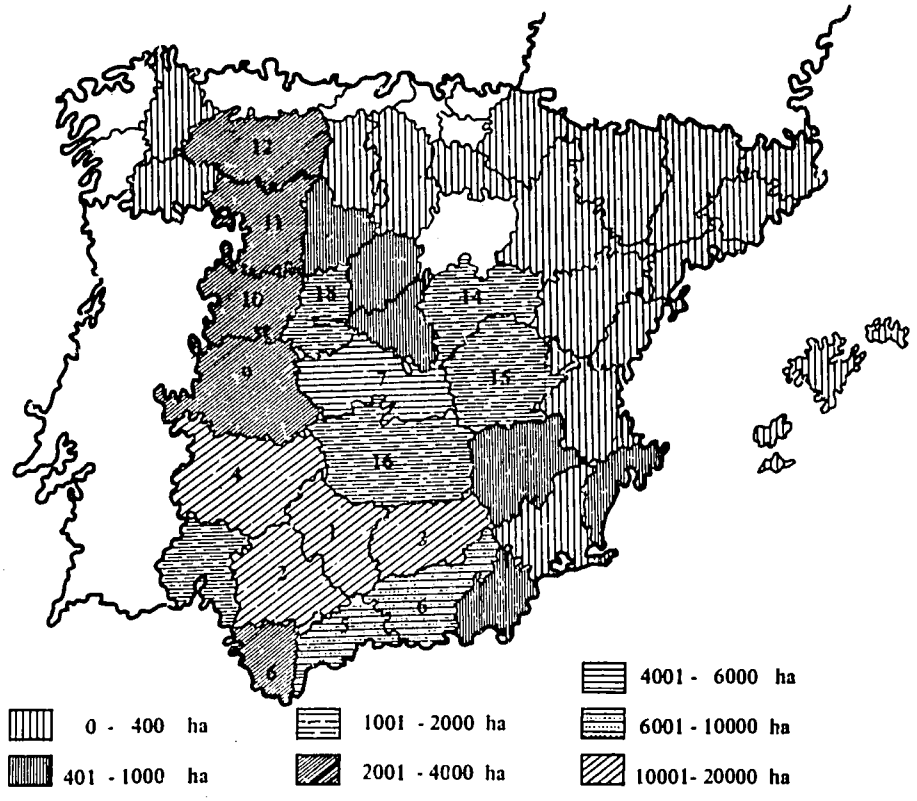

Figure 1. Chickpea cultivated area in Spain in 1978.
1. Córdoba, 2. Sevilla, 3. Jaén, 4. Badajoz, 5. Málaga, 6. Granada, 7. Toledo, 8. Cádiz, 9. Cáceres, 10. Salamanca, 11. Zamora, 12. León, 13. Avila, 14. Guadalajara, 15. Cuenca, 16. Ciudad Real.

chickpea imports; the present area could be multiplied by a factor of 1.5 at least. The farmers are asking to stop or at least not to increase these importations.

While diseases like ascochyta blight and fusarium wilt are also important limiting factors, Mexican imports are the biggest constraint to increased production.

Cultural Practices

Chickpeas have been traditionally a break crop in the rotation similar to a fallow. Thus there is a general lack of care in agronomic techniques used to grow them. The traditional sowing method commonly used in the pre-war period, and even

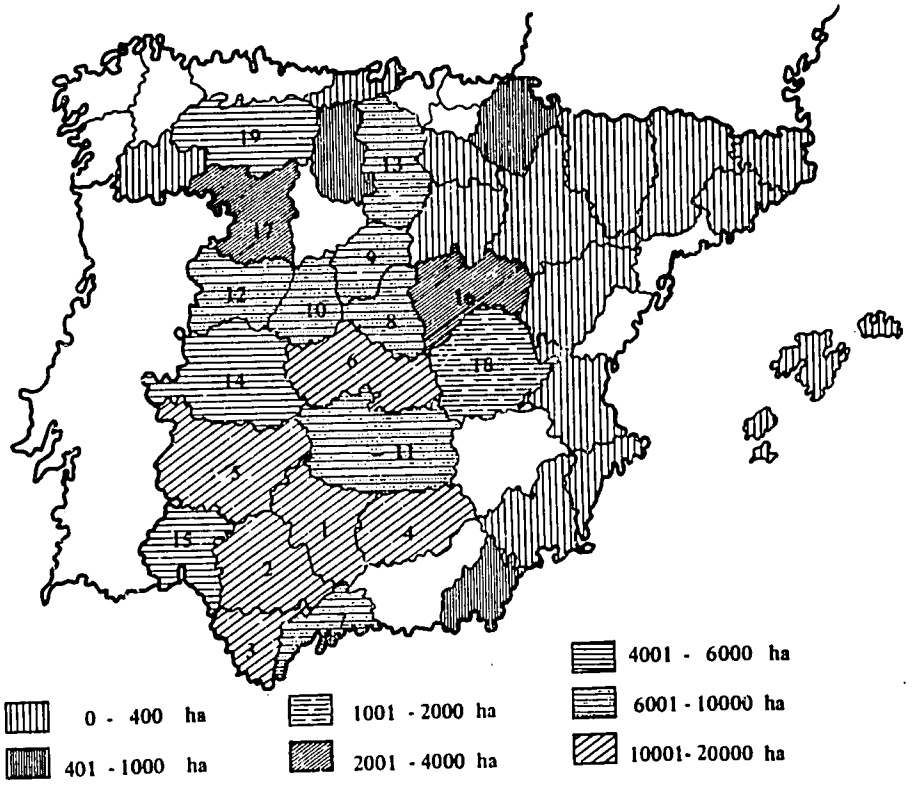

Figure 2. Chickpea cultivated area in Spain in 1922.
1. Córdoba, 2. Sevilla, 3. Cádiz, 4. Jaén, 5. Badajoz, 6. Toledo, 7. Málaga, 8. Madrid, 9. Segovia, 10. Avila, 11. Ciudad Real, 12. Salamanca, 13. Burgos, 14. Cáceres, 15. Huelva, 16. Guadalajara, 17. Zamora, 18. Cuenca, 19. Leon.

now by older famers, was to sow them in rows separated by 40–50 cm and only sowing two out of three rows.

The quantity of seed sown ranged between 50 and 80 kg/ha. Neither fertilizers nor pesticides were used, and weeding was performed by hand. The plants were harvested by hand pulling, earlier than fully matured and were allowed to dry before threshing by striking the gavels. Yields were about 500 kg/ha.

In more recent times, the high-priced varieties are sown by good farmers in better soils at higher densities (rows spaced 50–70 cm apart, and all of them are sown); fertilizers (mainly P and K) as well as pesticides (mainly cuprics against aschochyta blight) are applied. Sowing, harvesting, pesticide and foliar fertilizer applications are mechanically performed. Yields can reach 1000 kg/ha in

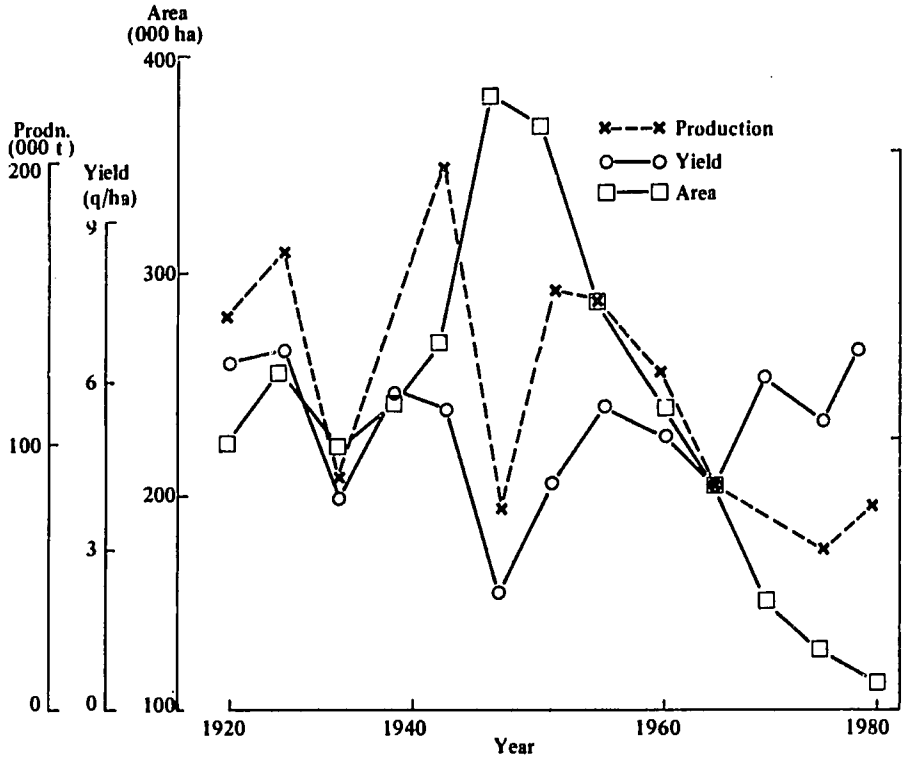

Figure 3. Evolution of the chickpea cultivated area, production and yield in Spain.

Table I
Chickpea imports and exports (t).

Year	Imports	Exports	Production
1968	3,319	603	141,300
1969	9,210	552	106,700
1970	21,633	181	89,300
1971	27,357	65	69,100
1972	30,045	524	88,000
1973	37,632	292	87,900
1974	24,745	2,256	78,100
1975	30,375	146	56,300
1976	31,928	249	55,000
1977	28,538	473	55,800
1978	55,874	2,622	71,000

Source: Anuario de Estadistica Agraria 1978.

Castille and even (1500 kg/ha) in W. Andalucía, but in many other places the yields are not so high because of both climatic and edaphic constraints.

The sowing date is generally in the second half of March; in Andalucía they can be sown late in February or early in March, according to the climatic conditions of the year. Harvesting is in June (Andalucía) to July (Castille).

Ascochyta Blight

Traditionallly, ascochyta blight ('rabia', 'quema', 'socarrina') was considered by farmers to be the most serious problem when growing chickpeas. The disease appeared suddenly after a short shower followed by sunshine, or after a late dew. This fact explains why many farmers and even old agronomists thought that blight was caused by the 'lens effect' of rain or dew drops. It also explains why many farmers in the severely attacked regions walked through the plots with a cord whose extremities were held in such a way by two men that the plant canopies were shaken, throwing most of the water drops off the leaves.

There are no data on the distribution of the disease for the pre-war period; comments by farmers suggest that it was endemic in all the regions cultivating chickpeas. Farmers do not realize the existence of different degrees of the attack so when they refer to the presence of 'rabia', they admit the complete loss of the harvest. It was usual to plow in the chickpea plants as soon as the first symptoms were noticed.

In the post-war period there are records of blight in all the regions (Table 2) but it is not possible to speak about 'epidemics', perhaps because the main area growing chickpeas, that is, the west of Spain, is cut into three subregions by two mountain chains. These subregions are characterized by different important agronomical features as, for example, growth rates of the crop, harvesting periods, daily temperature fluctuations, general climatic conditions, etc. (Table 3). Also, chickpea fields never formed a continuous carpet as is the case with other crops (wheat for example). Therefore the spread of the disease to a large area was never easy.

During the last fifteen years no serious ascochyta blight attack has been observed in the Cordoba province; in Seville province, good farmers growing chickpeas with modern techniques are much more worried about fusarium wilt than about ascochyta blight because they look for soils retaining enough water to support greater yields and also because they use both seed and plant treatments against ascochyta blight. In the Jaen province (more exactly in the 'Loma de Ubeda', i.e., Ubeda highlands, a zone traditionally growing chickpeas) one farmer has reported the existence of 'rabia'; in this case he was capable of separating ascochyta blight and fusarium wilt.

In Salamanca province (and probably in the Old Castille region) ascochyta

Table 2
Characteristics of 'Rabia' (ascochyta blight) attacks in different Spanish Provinces (from Puerta 1964).

Province	Disease importance	More affected zones	Yield[1] decrease	Years with disease out of every ten[2]	First symptoms appearance	Full attack date
ALBACETE	Some years Great	Heavy soils	50%	3–4	Seed filling	2nd half June
AVILA	Great	All	Max. 50%	10	Late May–Early June	2nd half June
BADAJOZ	Great	All				
CACERES	Great	All		9–10	May	Middle May
CADIZ	Great	All				
CIUDAD REAL	Great	All	20%–60%	10	Late May–Early June	June
CORDOBA	Huge	North 'Campiña'	60%	8	April	Middle May
CUENCA	Great	All	Max. 80%	6	May–June	June
GRANADA	Great	All				
HUELVA	Moderate	'Condado'	Ave. 20%	7–8	1st half of May	May–June
JAEN	Great	All	20%–60%	4–5	Flowering–Maturity	May–June
LEON	Great	All	Max. 60%	(10)3–4	Early June	Last third June
MALAGA	Huge	All	65%–100%	8–9	Before flowering	Flowering–Maturity
SALAMANCA	Great	All	Ave. 55%	2–3	May	Middle May
SEGOVIA	Great	All	30%–80%	(10)6–7	Late June	July
SEVILLA	Huge	All	25%–80%	(10)3–4	Middle April–Late May	10–20 May
TOLEDO	Great	All				
VALADOLID	Great	All	Max. 50%	(10)3	Late May–Early June	First half June
ZAMORA	Great	All	Max. 100%	6–7	May	May

1. First figure, average; last, maximum.
2. Between brackets, number of years with intense attack.

Table 3
'Rabia' attacks – environmental condition relationships (from Puerta 1964)

Province	Less affected landraces	Cultivated in	Relationships between disease intensity and weather conditions
ALBACETE	'Negros'	Highlands	Dew
AVILA	'Pedrosillanos'	All zones	High temperatures after rain or dew
CACERES	None		Heat and humidity
CIUDAD REAL	None		Low temperatures and rain
CORDOBA	'Rubio' 'Negros'	Sierra	Heat and humidity
CUENCA	None		Rain
HUELVA	'Mulato'	'Condado' and coast	
JAEN	'Mulato' 'Negros'		Cold and scarce rains
LEON			Dew and rain with high temperatures in late June
MALAGA	'Mulato' 'Negros'		20–25°C with humidity
SALAMANCA	'Pedrosillanos'	All zones	High temperature with hail stones and/or humidity
SEGOVIA	'San Pedro de Gaillos'		Rain or dew with insolation
SEVILLA	'Negros'		High or moderate temperatures with humidity
VALLADOLID	'Pedrosillanos'		Heat and humidity
ZAMORA	'Pedrosillanos'	All zones	Heat and humidity

blight, fusarium wilt and leaf miner are equally important; farmers do not use any kind of chemical. The 'rabia' attacks can be important, but only after late spring rains. In Badajoz, the 'rabia' attacks can also be severe. Farmers are starting to use fungicides aplied to the canopies. Finally, Prof. Mateo-Sagasta (formerly a member of the 'Estacion Central de Fitopathologia' in Madrid) advises that in recent years he has not observed attacks throughout Spain as severe as they were before; 'rabia' is severe in a 'patchy' pattern, depending on microclimatic conditions.

Summing up, it seems that ascochyta blight attacks can be severe when the precise climatic conditions are present; for the overall country they appear more as 'endemic outbursts' than as 'diasastrous epidemics.' The exact reasons for the possible decline in ascochyta blight importance in Spain are not known. Possible reasons are:

1. The decrease in chickpea cultivated area has produced a more scattered distribution of chickpea plots.
2. Farmers are using fungicides in some areas, increasing even more the 'patchy' pattern.
3. Some farmers grow chickpeas in better and more humid soils than the traditional ones with fusarium wilt appearing first.

4. The dynamics of the disease, with cycles ranging from extreme severity to an almost disappearance.

Research on ascochyta blight in Spain has been limited. In 1961, José Puerta set up for the first time a program on 'rabia' in chickpeas. Puerta (1964) studied the disease in different regions, described the characteristics, importance and frequency of its occurrence (Tables 2 and 3), examined the fungus from a mycological viewpoint, set up a screening technique for resistance and evaluated fungicides for the control. Cubero (1965) working with Puerta undertook mainly the mycological studies and determined the nutritional requirements and media conditions for the growth of the fungus.

Winter Sowing

It seems that winter sowings were previously in use in Spain but only for fodder. It is doubtful if they have been practised in the last 50 years.

Agronomists as well as farmers have received with great interest the possiblity of winter sowings. The aim would be to grow chickpeas only for human consumption; thus, the main socio-economic factor to solve would be to eliminate or to restrict the importations.

The lowlands of Andalucia are the best sites for winter sowings, followed by the Badajoz province. In these zones, winters are mild with extreme minimum temperatures of –5°C, excepting really exceptional years. The limiting factor here will be ascochyta blight attacks, and perhaps fusarium wilt in humid soils. In Castille there is an additional constraint – hard winters with temperatures going to –10°C. Resistance to low temperatures, as well as to ascochyta blight, would be essential. In between these two extremes (Andalusian and Castillian zones) there are areas where the late frosts may limit winter sowing. Here, adjustment of date of sowing coupled with frost resistance would be needed.

Spanish cultivars are large to extra-large seeded, so collections of these types would have to be tested.

Strategy for Introducing Winter Planting

Winter planting will require more fertilizers, more herbicides, more pesticides, more care of the crop and good farmers. Thus, the best zone would be the Andalucia lowlands.

In other zones, simple demonstration trials (date of sowing, pesticides, and fertilizers) would also have to be set up. Once the first results were obtained, different trials could be extended to other zones.

The role of research would include the study of collections in order to choose the most appropriate cultivars for each region. But most of the work to be done

would be pure extension. Diffusion of results can be made through the 'Hojas Divulgadoras' of the Extension Service, automatically distributed to all extensionists, and also through several journals in agriculture.

References

CUBERO, J.I. 1965. Studies on nutrient elements needed and medium conditions demanded by the fungus *P. rabiei* (in Spanish). Boln. Patol. Veg. Ent. Agr. 28:147–182.

PUERTA, J.R. 1964. Gram blight: isolation of the fungus *P. rabiei* and the study of gram varieties possibly resistant to it (Spanish). Boln. Patol. Veg. Ent. Agr. 27:15–52.

Closing Session

Recommendations of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas

The workshop was organized to focus attention on (i) the control of ascochyta blight of chickpea through the development of resistant cultivars as well as by other means and (ii) relative merit of winter sowing. The major recommendations that emerged from the workshop are summarized below.

Ascochyta Blight

1. The existence of races of *Ascochyta rabiei* (Pass.) Lab. was recognized and the need was felt to intensify work on this aspect with the possibility of subcontracting the work to an institution located in such a country where chickpea is not cultivated.

2. Sexual reproduction (perfect stage: *Mycosphaerella rabiei*) occurs in certain areas. There is a need to look for the perfect stage in other areas.

3. The perpetuation of *Ascochyta rabiei* through seed is well established. The minimum percentage of seed infection required for initiating an epidemic under favorable weather conditions needs to be determined.

4. Research be undertaken on (i) mode of disease spread, (ii) distance of inoculum movement, (iii) reasons for epidemics to occur in large geographically contiguous regions in certain years, but not in others.

5. Plant species, other than *Cicer* spp., which might be infected by *Ascochyta rabiei* and serve as a source of primary inoculum need be identified.

6. Recent work at ICARDA on the relationship between weather and disease should continue with the ultimate aims of devising ways and means to manage the disease.

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7. The role of crop debris as a primary source of inoculum be critically examined, particularly in areas where the weather remains essentially dry between two chickpea seasons.

8. The field screening procedure being followed at ICARDA is satisfactory, and cooperators may follow this at their respective locations. ICARDA/ICRISAT should consider assisting cooperators at 4 to 6 endemic locatons in developing proper facilities for screening.

9. The rating scale (1–9) developed by ICARDA/ICRISAT be followed at all locations to ensure better communication between workers.

10. Satisfactory progress has been made by ICARDA/ICRISAT in identifying sources of resistance to blight in both kabuli and desi types and these are being shared freely with cooperators.

11. In the absence of precise and detailed information on the nature of inheritance of resistance, it is suggested that lines showing resistance across locations as well as lines showing location-specific resistance be used to provide diversity in the material being generated.

12. Now that several sources of resistance are available, attempts should be made to identify different resistance genes/loci and to concentrate them within genotypes, which should help breeders in developing cultivars with durable resistance.

13. ICARDA and ICRISAT freely furnish segregating material at all stages to national programs to expedite the development of locally adapted, blight-resistant cultivars.

14. The work on development of cultivars with horizontal resistance should continue.

15. Some fungicides such as Calixin-M (tridemorph + maneb) seem promising in eradicating *Ascochyta rabiei* from seed. Work should be intensified on this aspect.

16. Research on identifying more efficient foliar fungicides than presently used should be continued.

17. Ascochyta blight is one of several important diseases. Attempts should be intensified to combine resistance to blight with resistance to other important diseases, pests, and parasitic weeds.

18. It is noted with appreciation that ICRISAT will appoint a fulltime pathologist to work on chickpea diseases. It is hoped that this appointment will be made in the near future.

Winter Sowing

1. Agronomy trials are needed over a wide area involving different agro-climatic situation. Special emphasis should be placed on studying the effect of planting date on the yield, yield stability, weed problem and symbiotic nitrogen fixation.

2. More research is needed on fertilizer responses which should be evaluated in relation to soil fertility and economic advantage.

3. Weed control research for identifying herbicides for both grassy and broad leaf weeds is needed.

4. Crop rotation research is needed to understand the potential role of chickpeas in comparison to other crops, particularly lentil.

5. In addition to blight resistance, winter sowing requires cultivars with cold and frost tolerance. Other aspects of physiological adaptation should also receive attention in breeding genotypes for winter planting.

6. Greater effort is needed to monitor pests and diseases other than ascochyta blight and assess their economic importance before research effort is expanded.

7. Macroeconomic research on supply and demand relations should be conducted.

On-Farm Trials

An important step should be made as soon as possible to move research onto farmers' fields. The timing of this step will vary across the region although some national programs are ready for this step now. The research should be simple,

involving only a few treatments on large plots, should be done within the prevailing rotation of the area and should involve farmers in conducting the operations. In evaluating the results and implications, farmers' opinion should be considered. The extension departments could be included in this research.

Seed Production and Rhizobium Inoculum

1. The simultaneous development of a seed industry is essential if the new ascochyta blight resistant cultivars are going to be adopted by a large number of farmers. Therefore, good quality seed needs to be produced in adequate quantities.

2. Seed should be produced (i) in areas where the blight does not occur naturally, or (ii) under blight-free conditions.

3. Seed should be routinely treated with fungicides like Calixin M. This is particularly important when seed is sent to nontraditional chickpea areas.

4. Since winter chickpeas might be introduced in non-chickpea growing areas, *Rhizobium* inoculum will have to be distributed along with seed. Inoculum production and distribution sources therefore will have to be developed.

Training

1. ICARDA/ICRISAT should organize regular training programs in chickpea breeding, pathology, agronomy, entomology, microbiology, etc.

List of Participants

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